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THE JOURNAL

OF THE

CHEMICAL, METALLURGICAL & MINING SOCIETY

OF SOUTH AFRICA.

VOLUME XIX.

JULY, 1918—JUNE 1919.

15-8319
6/1/21

JOHANNESBURG:
Published by the Society: Old Municipal Buildings, De Villiers Street.

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THE JOURNAL
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Vol. XIX JULY 1918. No. 1.

Submitted jointly to this Society and the Institution of Mining Engineers, London. The paper will be brought forward for discussion at the next meeting, 21st September, 1918.

THE EFFECTS OF DUST INHALATION.

By J. S. Haldane, M.D., F.R.S. (Hon. Member).

The disastrous effects produced by inhaling certain kinds of dust are now only too well known in mining communities. It is equally well known that no evident ill-effects result from inhaling certain other kinds. Thus coal-mining in Great Britain is on the whole a very dusty occupation; but as I endeavoured to show in a paper read two years ago,* there is no evidence in the mortality returns for either young or old colliers that dust inhalation has hitherto caused appreciable danger to life in British coal-mining. The wide-spread introduction of stone-dusting as a thoroughly practical and effective means of preventing coal-dust explosions has, however, directed new attention to the possibility of injurious effects of dust inhalation in coal mines.

The ill-effects from dust inhalation in mining have only been observed where hard rock is mined, and, practically speaking, only where the rock is in quartz, or stone such as granite, containing quartz. Observation not merely on mines, but also on quarrymen, stoneworkers, grinders, potters, and other persons exposed to dust from various forms of quartz or crystalline silica all tell the same story of dangerous injury to the lungs and death from phthisis after prolonged inhalation of quartz dust. The natural inference from these observations would seem to be that dust inhalation is dangerous in proportion to the amount of quartz or silica inhaled, and this was my own belief a few years ago. My opinions on the subject were, however, much shaken by observations made in the course of the work of the late Royal Commission on Metalliferous Mines and Quarries. We visited many quarries where hard stone containing about 70% of silica was being worked and dusty crushers were in use, so that men were considerably exposed to siliceous dust. I thought this dust must certainly be dangerous; but careful enquiry among workers, ordinary doctors, and medical officers of health failed to furnish evidence of injury. As an example of the sort of evidence we obtained there occurs to my mind the statement of a hale-looking old man who had been working about thirty years at dusty crushing mills. He said that the dust was not good to breathe, as it had a very fattening effect!

In 1911, while on a scientific expedition in the Rocky Mountains, I visited the gold mines of the Cripple Creek district. The stone worked is hard and contains about 70 to 80% of silica. Rock-drills were working everywhere without water-jets to stop the dust; and the men were evidently inhaling much dust; on careful enquiry however, I found that miners' phthisis or other lung injury from dust was unknown in the district, although it does occur at some other groups of mines in the Rocky Mountains.

When stone-dusting with shale-dust was first introduced by Sir William Garforth it was generally believed that the shale contains practically no crystalline silica, but only silicates. In writing to Sir William

*Trans. Inst. of Mining Engineers, LI., p. 469, 1916.

Garforth the letter on shale-dust inhalation, published at page 119 of the Report on British Coal Dust Experiments. I accepted this erroneous opinion, and was much surprised, and at first even somewhat sceptical, when, in the Fifth Report of the Home Office Committee on Explosions in Coal Mines, page 31, Dr. Mellor, the first authority in this country on the chemistry of silicates, stated in 1913 that he had found 35 % of quartz in the Altofts shale. A further investigation was kindly made at my suggestion by Professor Sollas, F.R.S., another great authority on the composition of rock. He used a quite different method from that of Dr. Mellor, but authorises me to say that he obtained just about the same quantitative result. We may, therefore, accept it as a fact that Dr. Mellor's analyses were practically correct, and that even the softest shale contains about a third of its weight of crystalline silica in fine particles.

In spite of this somewhat disturbing fact, it seems to me that the statistical evidence shows clearly that inhalation of shale-dust is harmless in practice. A few years ago it was tacitly assumed that the black dust lying along the roads and working faces of coal-mines is, practically speaking, pure coal-dust. The Altofts and Eskmeals experiments were an eye-opener in this respect. They showed that pure coal-dust is so easily exploded, and with such fearfully destructive effects, that it seemed difficult to see how destructive coal-dust explosions are not far more frequent than they are. Many of the mine officials and others who "found salvation" on the coal-dust question when they saw the experiments at Altofts must, I think, have returned to the fire-works at their own mines with a puzzled feeling that science and practice could not be quite the same thing.

The further experiments at Altofts showed clearly that the more stone-dust was added to pure coal-dust the less easily was the dust ignited, and the less violent were the explosions, till with 40 % of stone-dust it was very difficult to start an explosion, with even a heavy blown-out gunpowder shot; and the very careful further series at Eskmeals assigned 50 % of stone-dust as a limit at which neither the heaviest blown-out shots nor gas explosions would start an explosion, even when, besides the dust, there was as much as 3 % of firedamp in the air.

The apparent want of agreement between the Altofts demonstrations and ordinary practical underground experience is cleared up by the fact that the black dust actually present on the roads and at the face is hardly ever pure coal-dust, but usually a mixture containing a high percentage of stone-dust—often sufficient to make dust explosions impossible. This was clearly brought out in the investigations which were immediately made on the establishment of the Doncaster Coal Owners' Laboratory. Greatly to the relief of the management, it was found that along the roads and faces of their pits the black dust contained a high percentage of stone-dust. At Bentley Colliery, for instance, there was about 50 % of stone-dust in the small quantity of fine dust along the faces; and except near the pit bottom the percentage along the roads was about as high, or higher. The stone-dusting which was applied in order to give a large margin of safety was thus a comparatively easy matter, as shown in the paper read by Mr. Clive.* The late Mr. Fryar then arranged for the systematic collection of samples from a number of pits in the Nottingham district, and the analyses at the Laboratory of 179 samples from eight different seams gave the following average results for the dust passing a 90 mesh sieve.

Percentage of Ash

Places at which samples were taken.	Roof.	Sides.	Floor.
200 yards inbye of pit bottom	41·2	36·1	33·6
Half-way to face	38·1	42·1	37·7
200 yards from face	50·7	56·2	51·0

The Nottingham district has been practically free from dust explosions, so it must not be assumed that so much stone-dust would be present in other mines. The percentage is certainly often a good deal lower. But it is at least evident that for generations all coal-miners must have inhaled a great deal of stone-dust, and, therefore, a great deal of crystalline silica. The stone adjacent to Nottingham coal-seams is often full of crystalline silica, and almost more of a sandstone than a shale. A sample examined by Mr. Graham at the Doncaster Laboratory showed over 70 % of silica. Now in the Nottingham and Derby district the death-rate among miners from lung diseases

* Record of British Coal Dust Experiments by the Committee of the Mining Association of Great Britain, 1910, p. 119.

* *Trans. Inst. Mining Engineers*, XLVII., p. 59, 1914.

is, at all ages up to 55, not only, as with all coal-miners in England, far below the average for other employments, but even slightly lower than for farm labourers. The death-rate for phthisis alone is also slightly lower than for farm labourers. Among metalliferous miners living in Cornwall, many of whom had worked in the iron-yard, the corresponding death-rate from lung disease was, at middle age about fifteen times as great as among the Nottingham miners, and more than thirty times as great as their accident death-rate. It seems to me probable that the Nottingham coal-miners inhale about as much crystalline silica as metalliferous miners; but there are no ill-effects at all.

In gold mining in quartz reefs there seem also to be striking differences at different places as regards the danger of the work. At the Mysore mines, for instance, where the gold is in quartz, I am informed that there is but little trouble from lung affections attributable to dust; and in Western Australia there appears also to be only a moderate amount of trouble. In the Transvaal, on the other hand, the trouble has been of a most formidable kind, necessitating extremely drastic preventive measures.

The ill-effects of quartz-dust have been attributed to the sharpness of the particles, and their consequent irritant action on the lungs. But if so, one would expect the quartz-dust to prove irritant in proportion to the amount inhaled. One would also expect to find the sharp spicules in the lungs, whereas what is actually found consists of extremely fine particles, which do not look specially sharp or different in appearance from other very fine particles.

The whole matter was so mysterious that it seemed very desirable to try to clear it up by experiments on animals, and the Medical Research Committee under the National Insurance Act asked me to arrange for the investigation, and provided the necessary funds. The work was carried on in my laboratory at Oxford by Mr. A. Mavrogordato, and short references to results reached up to date were made in the report which I presented to the Explosions in Mines Committee in 1915.* Unfortunately the war has put an end to the work for the present. Before leaving it in order to take up other medical work connected with the war, Mr. Mavrogordato had, however, so far completed essential parts of the investigation that he was able to prepare a report to the Medical Research Committee, and this report is in process of publication in the "Journal of Hygiene."

The experiments were, like those reported by Professor Beattie to the Explosions in Mines Committee,† made on guinea-pigs. And I may say in passing that they confirmed in all respects Professor Beattie's conclusion that the inhalation of shale dust in amounts such as a miner would probably be exposed to is practically harmless.

From Beattie's experiments and the previous ones of Arnold‡ and others, it appears that any kind of dust particles, except, perhaps, when they are soluble and chemically harmless, will cause inflammatory changes in the lungs if enough of the particles are inhaled. The nose and air passages are, of course, a great defence against dust, and in some animals the convoluted surfaces inside the nose constitute a particularly efficient defence. The particles which fall against the surfaces of the nose and air passages are swept out by the action of the cilia lining these passages, or by coughing, etc. Nevertheless a considerable portion of the very finest dust reaches the lungs, and will cause harm if it is in sufficient amount. This harm, if caused immediately, seems to be much about the same with all sorts of dust. But if the harm is not caused immediately there is a great difference in the effects. Certain dusts, and notably any unmixed form of crystalline silica, cause lasting and cumulative injury; whereas others, and notably coal-dust or shale-dust, cause no cumulative injury, and no injury at all unless they are present in enormous amounts.

Now what happens to the dust within the lungs in these two cases? On this point the experiments gave a perfectly clear answer. When the animals were exposed to as nearly as possible equal quantities of the fine dusts, and for equal times, the dusts were, at the end of the period of exposure, found to be abundantly present in the lungs. With coal-dust there was special abundance, which is what we should expect considering its lightness and fineness. The lungs became quite black. But if the examination was made some weeks later, it was found that the coal-dust and shale-dust lungs were clearing up, whereas

* Seventh Report of the Explosions in Mines Committee Parliamentary Paper, Cd. 8 122, 1915.

† First Report of the Explosions in Mines Committee. Parliamentary Paper, Cd. 6707, 1912.

‡ Untersuchungen uber Staubinhalation und Staubmetastase, 1885.

there was no evident diminution in the dust in the lungs of animals which had been exposed to powdered flint or quartzite dust from a Transvaal gold mine. After several months the coal-dust and shale-dust had entirely disappeared from the lungs, whereas the flint and quartzite were nearly as abundant as immediately after the exposure to the dust.

The examination showed that all the dust particles are taken up into the protoplasm of certain of the epithelial cells lining the air-cavities of the lungs. In the case of the coal-dust or shale-dust these cells detach themselves and wander away with their load of dust-particles. Some pass directly into the ends of the bronchial tubes, and are thence swept upwards by the cilia and swallowed. They thus pass out of the body by the alimentary canal. Other dust-laden cells wander into the lymphatic vessels and are carried to the lymphatic glandular tissue surrounding bronchi. From this position they wander right through the walls of the bronchi, and are then swept out like the cells already referred to. Still other dust-laden cells are carried into the lymphatic glands at the roots of the lungs, and where they wander afterwards is still uncertain.

In the case of the flint or quartzite dust nearly all the dust remains *in situ*. It is only to a comparatively small extent that the cells wander out with it, though some wandering does occur, and some of the dust gradually reaches the lymphatic glands, where it can readily be recognised, as it becomes coated with a dark pigment.

It can now be realised readily what is happening in the lungs of a coal-miner breathing large quantities of coal and shale dust, as compared with what is happening in the lungs of a gold-miner breathing quartzite dust. As fast as the dust goes in day by day to the coal-miner's lungs it is carried out again by the dust-cells. His lungs, it is true, are probably always more or less black; but on the other hand what he coughs up is black and full of the dust on its way out again. His black spit is in truth his salvation. On exposing the animals to relatively small daily doses of coal or shale dust, and continuing this over a long period, it was found that after a few days the dust in the lungs ceased to increase. The intake of dust was thus balanced by the output. From all we know about similar physiological processes we may be pretty sure that the capacity for eliminating dust particles grows with use. If this is so the practice of constantly getting rid of coal and shale dust may help the lungs in eliminating other kinds of harmful particles such as tubercle bacilli, and may thus account for the remarkable fact that coal-miners are, and always have been since statistics were first available sixty years ago, extremely free from phthisis.

In the case of the miner breathing quartzite dust the dust remains for the most part *in situ* in the lungs, and there tends to accumulate from month to month and year to year. Some of it is certainly got rid of; but to reach a balance between intake and output, without there being a dangerous permanent loading of the lungs with dust, the amount of dust inhaled must be reduced to a minimum. The fate of men who have constantly, and often against constant warning and against the law, exposed themselves to heavy concentrations of quartzite or granite dust in working rock-drills and in blasting, is tragic. For many years back I have abstracted for the Home Office the information obtained by local Registrars in Cornwall as to the mining history of miners who have died there. Since the war no statistics have been published, but for ten years previous to the war the average duration of employment on machine drills of the men who died in the Redruth area, and had worked machine drills in the Transvaal only, was 4·7 years, and in Cornwall only was 7·8 years.* Practically every one of these men died of phthisis, and usually at an age below 40.

On the ultimate effects of chronic overloading of the lungs with dust I do not propose to dwell at present. It may suffice to mention that an over-development of connective tissue gradually occurs, constituting the condition of "fibrosis," and that at the same time the lungs become extremely susceptible to attacks by the tubercle bacillus, so that death from phthisis is the usual result.

Why is coal or shale-dust easily removed from the lungs, but not siliceous dust? And why, above all, is pure quartz so difficult to remove, while the large proportion of quartz in shale-dust is removed quite easily? Let us take the first question first. The evidence points to the fact that not only is quartz dangerous, but also other kinds of very insoluble crystalline dust. Thus Pro-

* Report for the Midland and Southern Division, Mines and Quarries, Parl. Paper, Cd. 7429 vi., 1914.

fessor Beattie found that emery, a crystalline alumina, and carborundum, a carbon silicide, are very dangerous. Now if it were the case that the danger is due to mere hardness or sharpness, we should expect to find that crystalline dust, even when mixed with other dust, is dangerous. But the quartz in shale and other hard stone is actually harmless in practice. The mere chemical composition of the stone does not seem to matter. There is, however, a quality in the dust that does seem as if it mattered, and this is its power of adsorbing other substances.

Adsorption or solid solution is a process distinct from chemical combination and similar to solution in a liquid. It depends upon attraction between the molecules of the adsorbed substance and those of any free surface on or in the adsorbing solid, just as solution depends on attraction between the molecules of the solvent and of the dissolved substance. The importance of adsorption in all kinds of processes used in industry is, of course, very great; and the recent remarkable experiments by Mr. Ivon Graham on the solution or adsorption of gases by coal* point out one direction in which adsorption is of great interest in coal-mining. Particles of coal-dust and other insoluble carbonaceous matter possess in a high degree the property of adsorbing other substances. The same property is possessed in a less degree by such substances as shale; while crystalline substances such as quartz seem to have very little adsorptive power.

Now we can well imagine that insoluble dust-particles are attractive and stimulating to dust-collecting cells in proportion to the soluble substances adsorbed in the dust-particles, and that the particles containing little of these substances will be correspondingly unstimulating. This, at least, seems to me the most probable explanation of why some kinds of insoluble dust stimulate the cells and others do not; and the facts so far known seem to be consonant with this explanation, though far more work on the whole subject is required.

To the second of the two questions the answer seems simpler. The particles of quartz are taken up by dust-collecting cells, as already mentioned, though the cells do not readily wander out with them. But if enough of the juicy adsorbent particles are also present, they will stimulate the cells sufficiently, and consequently the whole of the dust, including the quartz, will be removed. In this way we can see how a mixture of quartz with silicates, as in shale-dust and the dust from many coal seams, causes no harm. We can also see, I think, why the dust in the Transvaal gold mines is so much more harmful than in some other districts where the metal mined is also in quartz. In the Transvaal both the gold-bearing reef and the surrounding "country" rock is quartzite. The quartz dust is thus very pure. At Mysore, on the contrary, the country rock is not quartzite; and the dust is, therefore, a mixture containing, probably, enough of the stimulating variety of dust to stir the dust-collecting cells to activity.

On the subject of the Mysore mines and the "country" rock of the Transvaal mines, I am indebted for information to Dr. W. F. Smeeth of the Mysore Government Mines Department. In a letter he has kindly written to me he makes the following statement as regards the Mysore mines:—"The auriferous veins are composed of practically pure quartz; but the rock or 'country' in which the veins lie is composed of basic lava flows having about the following composition:—

SiO_2	49
Al_2O_3	14
Fe_2O_3 and FeO	14
MgO	6
CaO	11
Na_2O and K_2O	3

Owing to the small size of the veins a good deal of the 'country' is broken along with the quartz—perhaps 30 to 50 % of the former; and the dust is likely to consist of not much more than 50 % of quartz, with nearly 50 % of silicates."

Pressure of war work has prevented me from collecting from various mining districts the information I had hoped to bring forward on the question of the nature of the dust-mixture actually breathed by the miners, and the corresponding effects of the dust on the lungs. But I trust that valuable facts will be contributed in the course of the discussion.

If the presence of another dust can prevent the ill-effects of quartz or other dangerous varieties of dust, then we should expect to be able to verify this by experiment; and Mr. Mavrogordato was able, before stopping his work, to carry out experiments where coal-dust was added to

* *Trans. Inst. of Mining Engineers*, LII., p. 338 1917

the flue-dust breathed by the animals. The results indicated that practically the whole of the flue-dust was got rid of within a reasonable time.

Unfortunately, these very important experiments were only carried on under great difficulty, owing to war work, and their extension had to be postponed. It is evident, however, that the facts ascertained point to the possibility of attacking the problem of dangerous stone-dust in mines and elsewhere from a new side, and in a manner strangely similar to that in which Sir William Garforth attacked the coal-dust problem. If we cannot altogether prevent the inhalation of dangerous stone-dust we can apparently neutralize its effects by causing another kind of dust to be inhaled along with it. Dust from pulverised clay or shale, or a mixture of coal-dust with shale-dust, would seem to be suitable. A black mixture of, say, 60 of shale with coal-dust might be specially suitable, as it would be easily visible, and could not explode. The most suitable method of applying it so as to ensure that the men should breathe enough of the dust would have to be carefully thought out; but I do not see why practical success should not be reached, particularly if the existing precautions against inhaling quartz-dust were vigorously maintained. The less quartz-dust is inhaled, the less of the neutralizing dust will be required, just as in the case of coal-mines the less coal and coal-dust is deposited along the roads the less stone-dust will be required.

Experiments as to what other kinds of dust are dangerous besides quartz had to be postponed meanwhile. Much to our surprise it had been found that the flue-dust which has been used at some collieries for stone-dusting is a kind of dust which is not readily eliminated, and would probably, therefore, be dangerous if inhaled without admixture. It seems almost certain, however, from what has been already said, that flue-dust, when breathed along with coal-dust, would be practically harmless. Even if a coal-mine was stone-dusted with quartzite stone-dust like that of the Transvaal mines I doubt whether much harm would result: though I certainly should not think such an experiment justifiable.

The need for further experiments on the effects of inhaling different kinds of dust, and on the conditions needed for neutralizing the ill-effects on the lungs, is very evident, but as the practical conclusions which can be drawn from what has already been discovered are both evident and important, it seemed worth while to give the present summary. Observations of mining engineers on the effects of dust inhalation and the accompanying mining conditions in different mining districts throughout the world would, of course, be a most valuable help in guiding future experiments and devising effective methods of preventing the terrible suffering and loss due to miners' phthisis and fibrosis.

As far as coal-mining is concerned the results of the investigation are fortunately very re-assuring. So long as the dust in a coal-mine is not explosive, and is not breathed in excessive quantities, it seems to do no harm, and possibly even does some good.

Obituary.

MR. J. S. CURTIS.

The death is recorded with sincere regret of Mr. Joseph Storey Curtis, one of the foundation members of the Society, owing to a sudden and severe attack of pneumonia.

Mr. Curtis was one of the first American mining engineers and geologists to arrive in South Africa in 1886, when with Mr. Gardner Williams he visited the Rand and Barberton. His first undertaking was the laying out of the Robinson mine, and subsequently as a firm believer in the deep levels, demonstrated their payability by putting down the first bore-hole on the Village Main Reef Mine, of which he was the managing director.*

In the stormy days of 1895 he took a keen interest in Transvaal politics, which resulted in his becoming one of the Reform prisoners, while he was also closely associated with horse-breeding and racing in those days.

During later years, Mr. Curtis retired from active mining work, and while occasionally contributing to the discussions on various subjects before this and kindred societies, his chief work was in the preparation of a history of the Witwatersrand. In the words of the Rev. Digby Berry, who conducted the service at Brixton Cemetery, Mr. Curtis "was a fine American gentleman."

* See this *Journal*, Vol. XII., July 1911, p. 32.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

ZIRCON FROM BRAZIL.—"According to the *Iron Age* Brazilian zircon is becoming a marketable product in the United States, being saleable at $50 to $60 per ton. Zircon is used chiefly in the manufacture of refractory crucibles and for the refractory linings of furnaces. Silicate of zirconia, the mineral known as zircon, is found in small crystals mixed with monazite in the sands, out of which the Brazilian monazite is washed. In the process of recovering monazite from these sands the zircon and the ilmenite (black oxide of titanium and iron) are separated. As the ilmenite has apparently no commercial value it is thrown away, but according to exporters, zircon can be marketed at $50 a ton with a small profit, in spite of high freight rates. With the present electric separating machines it is practically impossible to remove all the monazite from the zircon, and a residuum of 2 to 6 of monazite, of small value and very difficult to recover, is bound to remain with the zircon." *Indian Engineering*, Jan. 5, 1918, p. 9. (J. A. W.)

GRAPHITE IN MADAGASCAR.—"The deposits extend for a distance of 400 miles, and so far only the outcrops have been worked. The bulk of the graphite is in the form of thin flakes from $\frac{1}{8}$ in. diameter down to fine dust, the amorphous variety being rare; as dug out the ore contains 60% graphite, but only a third of this is recovered by present methods of dressing. Of this 60%, containing 90–96% carbon, is suitable for crucibles and furnace linings, while the remainder (fine dust) is used for other purposes. Some deposits contain a large mixture of mica and iron, and await the development of a satisfactory separation process. The deposits are worked by native labour employing their own crude methods of hand washing, etc., and Mr. Shetley suggests that the staff, that is at present producing 25 tons of marketable graphite could with labour-saving devices secure 250 tons. The working cost at the mine averages £9 a ton, and with inland transport, shipping, taxes, etc., added, the total cost amounts to £17–£19 per ton c.i.f. London, under normal conditions. In 1913 about 120,000 tons of graphite of all kinds represented the world's production. Ceylon produced 40,000 tons and Madagascar 8,000 tons, though the 1915 production of the latter was estimated at 12,000 tons. The graphite exports of Madagascar have risen to the latter figure from 19 tons in 1909. The production is exported to Europe, and used: 60% for crucible retorts, 15% for furnace and converter linings, 10% for paint, 10% for lubricant, and 5% for foundry moulding. Great possibilities await the development of the graphite industry in Madagascar."—JOHN W. SHETLEY.—*Indian Engineering*, Feb. 16, 1918, p. 93. (J. A. W.)

METALLURGY.

CHARCOAL AS GOLD PRECIPITANT.—In April, 1916, the writer made numerous laboratory experiments on the precipitation of gold by charcoal which gave such encouraging results as to justify them being continued until a commercial process was evolved. In August of the same year a plant was installed at the Yuanmi G.M., Ltd., where it has since been working continuously with most satisfactory results, and precipitation of gold by means of zinc has been completely discarded.

As a detailed description will shortly be published dealing with results obtained in experimental work, with the theoretical side of charcoal precipitation and also with details of plant required, it will suffice here to briefly consider the more salient features of the process.

The main points established are as follows:—

(1) Charcoal is a more efficient precipitant if quenched red hot than if cooled slowly.

(2) Fine grinding, especially wet grinding, further greatly increases its efficiency.

(3) A suitable source of charcoal where wood is used as fuel, is the ash pit of any wood burning furnace. The hot ashes are quenched in water, washed free from ash proper and the remaining clean charcoal finely ground wet.

(4) Agitation of the solution to be precipitated with charcoal is not necessary; filtration through cakes of ground charcoal suffices, thus greatly simplifying the process.

(5) It is impossible to efficiently carry out precipitation in one stage as either high tails will result, or only a portion of the precipitating energy of the charcoal will be used. Filtration through at least two and preferably through three charcoal cakes is required.

(6) Filtration would be too slow unless assisted by pressure or vacuum. It is also indispensable that the cakes should be of even permeability, otherwise channelling with consequent imperfect precipitation ensues. The Moore-Edmands Vacuum Extractor was specially designed to give an absolutely even cake, and is in successful operation here.

(7) A simple means had to be devised to burn the gold-laden charcoal, leaving an ash free from carbon and avoiding loss from dusting.

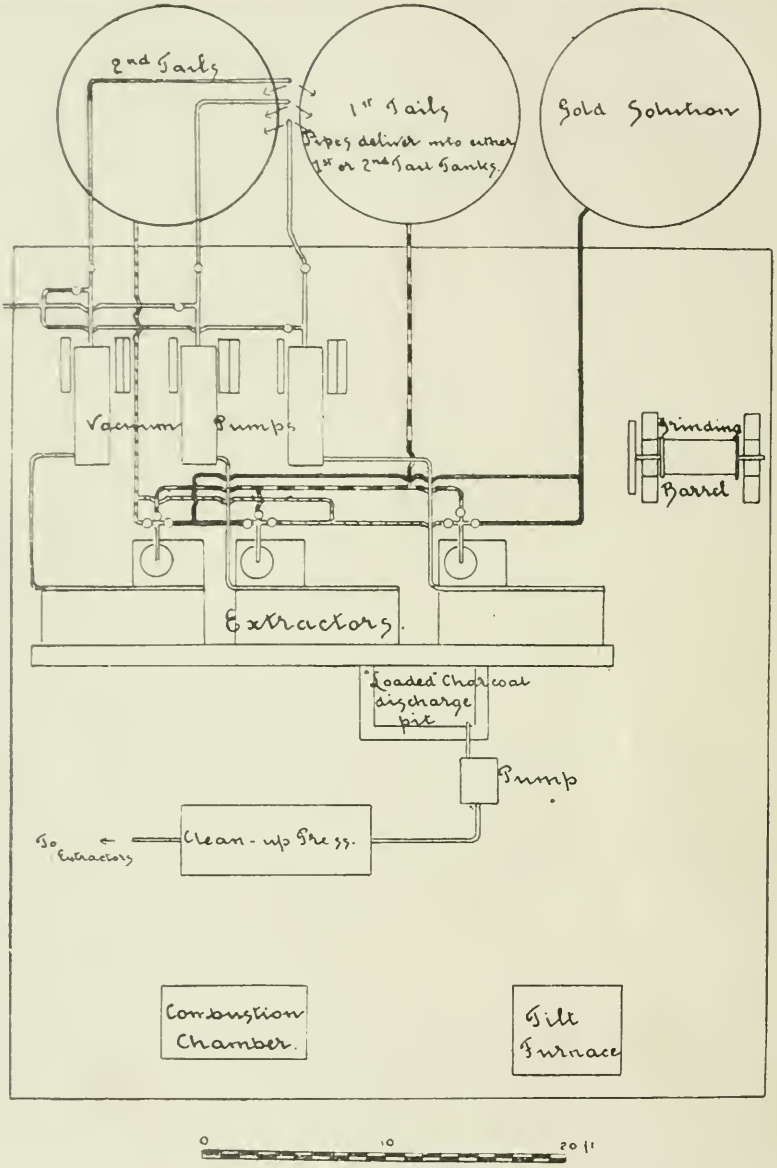
Method of Working.—Grinding.—The red hot ashes, after quenching are transferred to a basket of heavy wire screening, about $\frac{3}{8}$ in. aperture, tossed in a trough of water to remove ash, and the clean charcoal ground wet in a C.I. Barrel, 4 ft by 2 ft. diameter containing balls. This discharges the ground charcoal pulp into a box, whence it is pumped as required to extractors.

The bars of the furnace whence the ash is obtained should not be spaced too wide, otherwise much hard charcoal will result, the finer and softer charcoal gives the better results.

Precipitation.—Three Moore-Edmands extractors are used. They are rectangular vessels, 8 ft. long by 2 ft. 6 in. wide by 5 ft. 3 in. deep, with 'V' shaped bottoms and are constructed of $\frac{1}{8}$ in. steel plate or even of plain galvanised iron. Each extractor carries 21 filter leaves similar in principle to those used in vacuum slime filtration, the size of each being 2 ft. 3 in. by 2 ft. 9 in. They are connected, *via* a manifold, with a wet vacuum pump attached to each extractor.

Four propellors, with thrust in alternate direction and mounted on a horizontal shaft revolving in the extractor under the filter leaves, provide efficient means of agitation.

Solution is maintained at a constant level in the extractors by a float valve of special design—A. An auxiliary float, connected to an electric bell, gives warning should the solution level be too high or low.



General Arrangement of Plant.

The three extractors are connected to three vats containing respectively, gold solution to be precipitated, 1st tails and 2nd tails.

The pipe system is best arranged so that each extractor may be connected at will with either of these three vats.

About 300 lb. charcoal is the usual charge for an extractor and the flow of solution is as follows :—Gold solution flows through 'A' extractor and is delivered to the 1st tail vat, thence it flows through 'B' extractor to the 2nd tail vat, thence finally through 'C' extractor to any part of the treatment plant as required.

When the charcoal in 'A' is sufficiently charged with gold it is run out, pressed, washed and burnt. Its removal is effected by releasing vacuum and continuing propeller agitation until the charcoal cakes are thoroughly emulsified, when the pulp is run by gravity into a sump and pumped to clean-up press. Extractor 'A' is then again charged with 300 lb. fresh charcoal, but by alteration of valves now receives solution from 2nd tail vat, becoming the third unit in the system, 'B' being the first, dealing with gold solution and 'C' the second, taking tails from 'B.'

Similarly, when 'B' has a full charge of gold it is discharged and re-loaded, becoming the third unit, 'C' the first and 'A' the second. In effect the principle is similar to counter-current decanta-

tion, the flow of solution and charcoal being in opposite direction.

The reason for using stage precipitation is obvious. Without it the final tail solution would rise in value long before the precipitating energy of the charcoal was exhausted, and a greater quantity of charcoal would be needed to maintain good precipitation, but by its adoption, this energy is used to the fullest extent, and the amount of charcoal required is correspondingly reduced.

It is found that not very much precipitation takes place in the first unit, yet it serves a useful purpose in removing certain salts from the solution, notably calcium sulphate, and thus prolonging the precipitating activity of the second and third units by preventing their precipitation there.

The capacity of the extractors of the size described is about 420 tons solution per day. One extractor is discharged and re-loaded at intervals of two and three days alternately, and each day the vacuum is released for a few minutes from each extractor, the charcoal cakes dropped and re-emulsified and, on again applying the vacuum the cakes are re-formed. This occupies only a short time and ensures maintenance of the even permeability of the cakes.

Clean-up.—The gold-bearing charcoal, after being discharged as described, into the sump, is pumped into a small clean-up press and washed to remove as much calcium sulphate, etc., as possible. About 600 gallons clean water, free of course from suspended matter, is required per charge of 300 lb. charcoal. The cakes are then freed from excess of moisture by compressed air.

The charcoal, without any further drying, and still containing rather more than 50% moisture, is now ready for burning.

Burning is effected by putting the damp charcoal into 'Braziers,' which are simply rectangular vessels constructed of heavy wire screening, $\frac{3}{8}$ in. to $\frac{1}{2}$ in. aperture, and measuring 18 in. by 18 in. by 18 in. At the bottom of each brazier a few live coals are placed, when ignition of the damp charcoal cakes soon commences.

The braziers are placed in a sheet iron combustion chamber, locked up and left. Combustion proceeds slowly for about 48 hours, when all the carbon is burned and only the gold bearing ash remains for treatment.

There is no loss by dusting and no attention is required.

Smelting.—The ash is very basic and requires plenty of sand and about 40% of borax for smelting. A partial analysis of a sample showed the following :—

	Per cent.
CaO—free—	21·65
$CaSO_4$	28·6
S (as sulphide)	0·2
CaO combined with silica, etc.	0·0
Insol. residue	6·7
FeO	9·6
Au	10·5

Smelting is effected in a tilt furnace using graphite pots, the corrosion on pots is less than with zinc precipitate, and slag value, after amalgamation is about 300s., which is also very considerably below that of slag from zinc precipitate.

The purity of the bullion produced is much higher.

Possible Alternative to Smelting.—The writer is at present working on an alternative wet method for ash treatment.

It is found that the gold in this ash is readily soluble in cyanide, but the best method of precipitation is still under consideration. The successful application of a wet method might effect considerable economies in fluxes, pots and coke, especially desirable at present war prices.

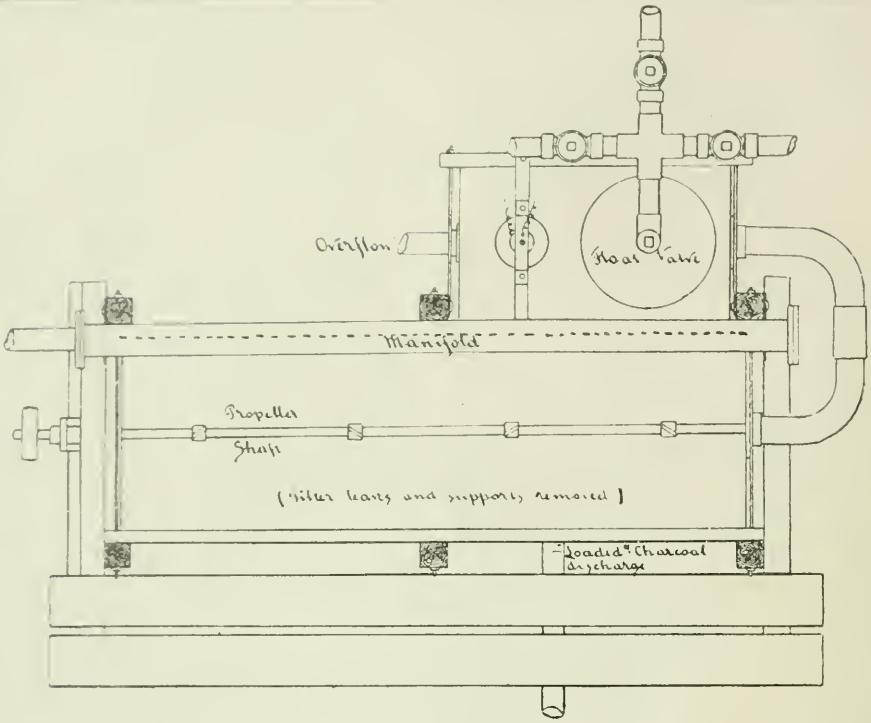
Comparison of Charcoal with Zinc.—The solution precipitated at the Yuanmi Gold Mines results from the treatment of roasted sulphantimonial ore containing arsenic. Sulphur enters the solution in various forms, largely as $CaSO_4$, from combination with calcite, which also occurs in the ore, and forms a practically saturated solution. Arsenic and antimony further complicate matters.

Precipitation was originally effected on zinc shaving which was not entirely satisfactory even when treating oxidised ore only. When a mixture of oxidised and roasted sulphide ore was milled, shaving had to be abandoned in favour of zinc dust, which yielded fairly good results until the supply of oxidised ore ceased and sulphide ore alone was treated, when precipitation troubles again arose and were finally solved by the introduction of the new charcoal process.

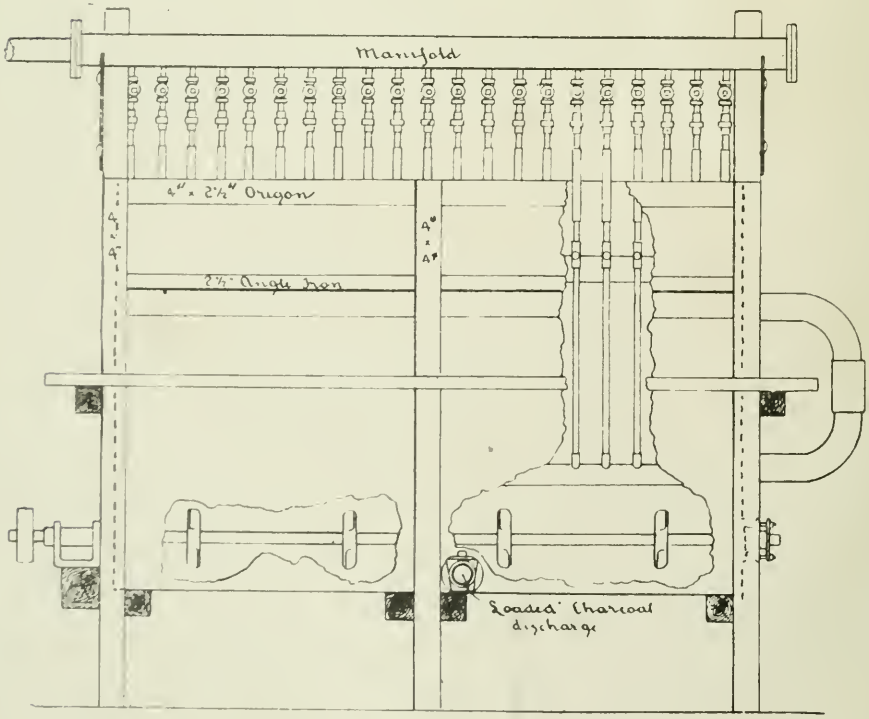
The following figures are the averages of some months work, but the quantity of solution precipitated represents rather the amount available than the capacity of the plant, which latter is 420 tons per day with charcoal and somewhat less with zinc dust.

These figures show a decided gain in efficiency by substituting charcoal for zinc, the latter leaving eight times as much gold in solution.

	Zinc Dust.	Charcoal, First Few Months.	Charcoal, Later Practice.
Tons solution precipitated per 24 hours ...	237	279	265
Tail value of solution	1·45/-	0·32/-	0·175/-
Percentage precipitated	92·8	97·6	98·7
Percentage of fine gold contained in material to be smelted (ash or calcined precipitate)	19·0	10·2	9·6

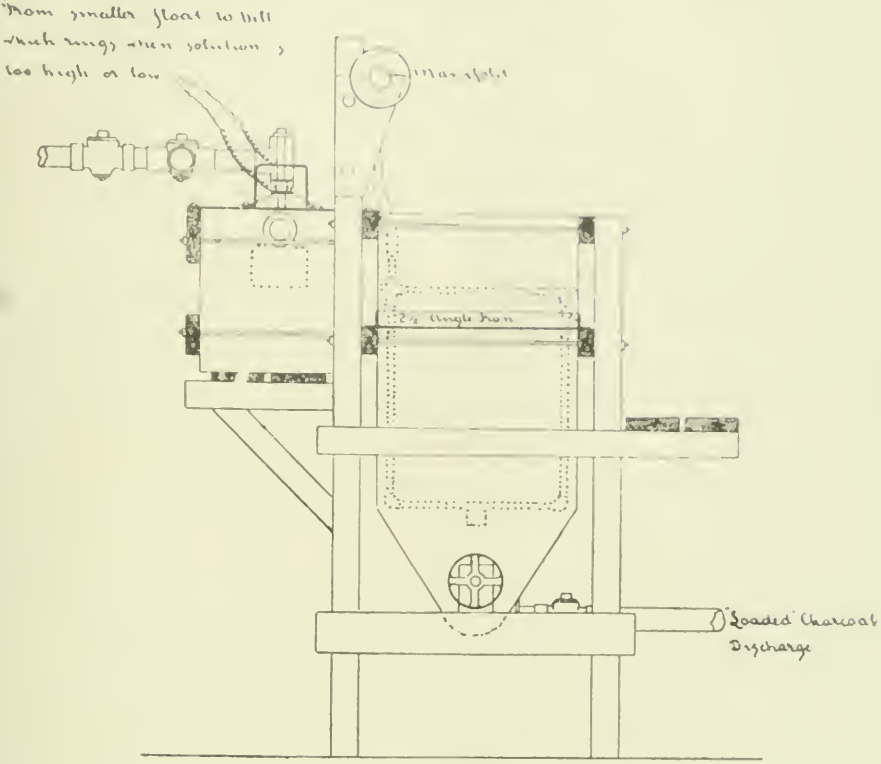


PLAN

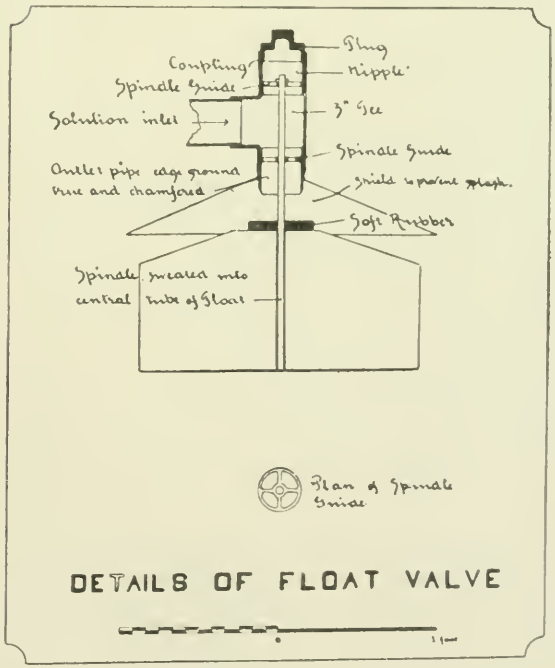


FRONT ELEVATION

Moore-Edmands Extractor.



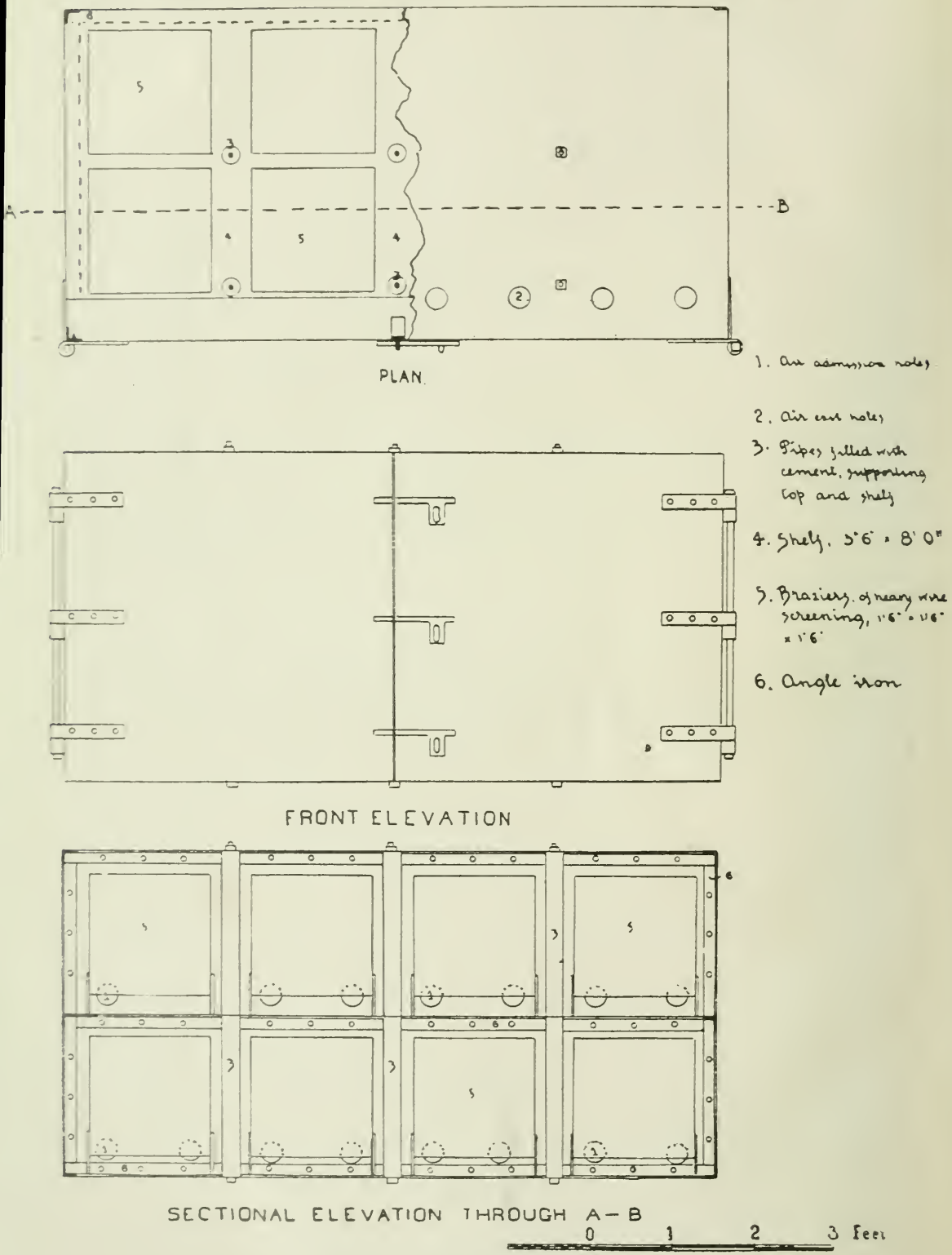
END ELEVATION



DETAILS OF FLOAT VALVE

0 1' 2 3 4 5 6 7 8 ft

Moore-Edmands Extractor.



Charcoal Combustion Chambers.

The average fineness of the bullion produced was :—

	Zinc Dust.	Charcoal
Gold ..	825·2	954·4
Silver ...	21·9	7·0
Base	152·9	38·6
	1,000·0	1,000·0

Relative Cost of Charcoal and Zinc Precipitation. assuming an average monthly output of 1,500 fine oz. gold, or 1,817·8 oz. and 1,517·7 oz. bullion for zinc and charcoal respectively (based on the figures given for respective fineness) the cost would be :—

	Zinc	Charcoal
	£ s d	£ s d
Bank and mint charges	78 13 5	54 11 1
One ton zinc dust ..	115 0 0	
Calcining precipitate, 2 tons wood	1 0 0	
Sulphuric acid	11 0 0	
Lead acetate used in extractor, 250 lb. at 8d.	8 6 0	
Grinding 1½ tons charcoal, power and repairs	-	1 10 0
Borax, 35% on 540 lb. zinc precipitate = 190 lb. at 1s.	9 10 0	
Borax 40% on 1,030 lb. charcoal ash = 412 lb.	—	20 12 0
Coke, 30 cwt. and 50 cwt. respectively at 9s. 8d.	14 10 0	24 3 4
		100 16 5
Balance in favour of charcoal		137 3 0
	£237 19 5	£237 19 5

Pots are not included in above. They last rather longer with charcoal.

To the direct monthly saving of £137 3s. must be added the even more important gain effected by lessened dissolved gold losses. The direct saving would, of course, fluctuate greatly with price of supplies, etc., but would be considerable even with zinc at a nominal price.

Compared with precipitation on shaving, charcoal has the disadvantage of greater first cost for plant. The extractors, if constructed on the mine, can be made for under £70 each, if of ⅛ in. sheet steel, and less if made of plain galvanised iron. The latter is quite satisfactory, but the former is probably better for permanent work.

The braziers and burning chambers are simple in construction

The floor space occupied is less than that required for zinc shaving. Less attention is needed and the clean-up is much simpler, the absence of aciding being in its favour. The charcoal is not touched by hand after being fed into the grinding barrel until it is put into the braziers.

One man is employed, day shift only, to fill, discharge, press and burn the charcoal, to re-form cakes in extractors and to maintain filter leaves in good condition by occasionally scrubbing with dilute acid.

Calcium sulphate and other lime salts give some trouble both with charcoal and zinc, with the former it gives a larger amount of ash to be smelted, and should, therefore, be removed as far as possible by washing in the clean up press. It does not appear to materially affect precipitation and generally charcoal is less sensitive to the action of many impurities which have an adverse action on zinc. This is shown by results obtained in practice, as also in laboratory experiments.

Treating solution from unroasted ore there is little doubt that the percentage of gold in the ash would be greatly increased.

The success of the process is largely due to the Moore Edmands extractor, the joint invention of Mr Karl Byron Moore and the writer, and valuable suggestions and assistance were given by Mr Moore in developing the scheme of charcoal precipitation.

It is possible that the fact of charcoal precipitation having been employed in Australia in the early days of cyanide treatment, and its having proved less efficient and more cumbersome than zinc, will militate against its speedy adoption here, even in an improved form—yet as a year's continuous run at the Yuanmi Gold Mines has conclusively shown it to give better precipitation at a less cost, to be less troublesome to handle and clean up, and to yield bullion of greater purity, it appears to the writer that it must eventually displace zinc, as it is impossible the gold mining industry will for long continue to purchase zinc and acid to do work that can be more efficiently and conveniently performed with a waste product."—H. R. Edmands.—*Journal of Ch. of Mines of Western Australia*, Sept., 1917, p. 214. [H. A. W.]

MINING.

Sinking Through Wet Strata.—"*Sinking by the Congelation Process in Stages.*—The congelation process can be carried out in three ways. In one method, boreholes are sunk in a ring round the shaft: but where the congelation is only commenced at a depth of, say, 400 yards, the putting down of this circle of holes is, so far as the first 400 yards are concerned, unproductive, or, at any rate, a burdensome expense. Moreover, some of the holes will be certain to have deviated so far from the vertical as to be useless for congelation: and where the rock is of a particularly unfavourable character, for instance, steeply pitched and extensively fissured, a set of supplementary bore

holes will undoubtedly be required. Another point is that, as the congelation progresses, the completion of the frozen wall round the shaft is liable to endanger the lining of the upper part of the shaft.

In a modification of the process, channels are provided in the upper lining for the subsequent boring of the ring of holes. The difficulty in this case is to maintain the verticality of the holes, and to keep the channels open. In the stage between 400 yards and 500 yards, the boreholes may deviate considerably, either inward or outward; and in the former case, such of them as come within the area of the shaft must be so far apart as to be equally useless for the lower portion of the frost wall; so that, in either case, supplementary bores will have to be sunk from the surface. Even in the unlikely event of all the holes being sufficiently near the vertical, they will be quite close to the shaft lining in the wet zone, and consequently will not give a strong frost wall, even with a great expenditure of refrigerating material, experience having shown that the frost wall does not extend very far outside the ring holes. In this method too, the lining of the upper part of the shaft is likely to suffer injury, through the possible inrush of water at high pressure. The two methods are therefore only suitable for cases where the widening of the shaft bottom is impracticable.

In the third method, the boreholes are drilled from the interior of the shaft itself, the shaft bottom being widened conically, commencing at a height of about 30 ft. above the wet zone, and lined with masonry, concrete, or tubbing. A number of stand pipes are then set up, with an outward slope, on the widened bottom, the quantity required and the angle being determined, for each case, on the basis of experience. A string of casing is attached to each stand pipe and led up to the surface, the shaft bottom being then flooded, and the boreholes drilled through the casings.

It will be evident that, in putting down these holes, considerable experience will be needed, and that chance plays an important part. Whilst, at first, the holes will follow the direction of the stand pipes, the bits soon begin to get out of line, and draw towards the perpendicular. How soon, and to what extent, this happens cannot be controlled. In some strata they follow the original line so long that the holes get too far away from the shaft; whereas in other holes the bits get into the vertical so quickly that the holes remain close to the sides of the shaft, the unfavourable results already mentioned ensuing.

In all cases, the deviation of the holes from the vertical must be carefully measured with reliable instruments, in order to obtain a proper idea of the thickness of the frost wall. Even if some of the holes are so far out of true as to be useless with a small supply of refrigerating material and moderate freezing temperature, they may still be utilised for the process by increasing the supply and lowering the temperature. Those that are too far out of line cannot be replaced by supplementary holes from inside the shaft, as the shaft is under water; whilst the shaft cannot be pumped out, because the boreholes already sunk afford communication between the water-bearing zone and the shaft itself. It is true that supplementary boreholes can be put down from the surface, but their direction is a matter of chance, and they may even connect with the good holes already sunk, so that more harm than good results.

For the reasons given above, the largest possible number of boreholes should be put down from the start, for then, even if some of them should prove useless, there is the hope that, with good freezing plant and the maintenance of a low temperature, a complete frost wall will be obtained. On this account, a carbonic acid plant is preferable to the ammonia system, by reason of the lower temperature that can be produced; and the plant should have a capacity of $1\frac{1}{2}$ million calories per hour.

Sinking the shaft from 400 yards to 500 yards will take about 28 months, divided as follows:—Widening the shaft conically, one month; setting up the stand pipes, fixing the casing, and partially filling up the widened space with sand or concrete, if necessary, three months; putting down and testing the boreholes, and installing the refrigerating and down pipes, six months; freezing, up to the time of commencing the sinking (assuming that the wet zone contains no saline liquors or flowing water), four months; net time of sinking, eight months; drawing the casings (down to 400 yards), and lining the widened portion of the shaft, four months; and caulking the tubbing rings, two months.

Experience has, however, shown that this calculated minimum time is always exceeded in practice, there being always at least one stoppage of work through inrushes of water. If there is no breakage of the freezing pipes, the damage can be made good in about six months; but if the brine escapes into the surrounding rock, the stoppage may last for years. Some experts even reckon on 12 months as the minimum for repair after a small inrush of water, because there is almost always supplementary damage to be made good.

The sinking proceeds as in the ordinary congelation process, but with great care, owing to the fact that the boreholes are close to the shaft, so that the frost wall is not very strong. It is advisable to follow up the sinking by tubbing as quickly as possible, time being saved, as in the case of the Borth shafts of the Solvay-Werke, by putting in temporary tubbings.

The cost of sinking per yard run fluctuates very considerably, depending on the nature and temperature of the rock and the presence of saline or flowing water; and, of course, the total efficiency of the refrigerating plant and the cost per ton of steam or kilowatt-hour form an important factor. In order to maintain the efficiency of the refrigerating plant at the maximum, accurate measuring instruments should be provided, to enable the progress of the work to be followed closely. Apart from the usual pressure gauges and thermometers, it is advisable to instal self-registering steam meters and thermometers at each engine, with thermometers and self-registering liquid meters in the path of the cooling water and brine.

The loss that may be sustained through uneconomical working of the engines may be gathered from the following calculation: The (condensing) engines of two refrigerating plants for 800 horse-power per hour should have consumed $13\frac{1}{2}$ and 22 lb. of steam per horse-power hour. In the case of the second one, the excess consumption in a run of 18 months was $41\frac{1}{2}$ tons of steam, equivalent to over £5,000, or £50 per yard of shaft sunk.

Similar losses are experienced when the cooling water available is too warm and in short supply.

A CO_2 plant, with a capacity of 1½ million heat units per hour and a vaporiser temperature of −25° C., has, in one case, an ample supply of cooling water at 10° C., and in the other a deficient supply at 25° C. In the former case, with a pressure of p=60 atmospheres in the condenser, and the plant running without waste, the output will be 2,472 heat units per horse power hour, whilst in the other the values will be 80 atmospheres and only 1,578 heat units. If the compressor in both cases has an efficiency of 80%, the output per horse power hour in the former is about 1,798 heat units, but in the latter only 1,262 heat units. To produce 1½ million heat units per hour, the first engine must develop 1,188 horse power; that is to say, the plant would require to be 430 horse-power hour larger, which, in 18 months, would mean an increased steam consumption of 55,728 tons, equal to about £7,200, or £72 per yard sunk.

As regards the question whether steam or electricity is preferable as motive power, the refrigerating plant requires about 633 kw. per hour, assuming the polyphase motors have an efficiency of 93%. At ¼d. per unit, this would cost about 17s. 6d., for which price 6¾ tons of steam could be generated. To give the same efficiency, a steam engine would consume 18½ lb. of steam per horse-power hour. With purchased current at ½d. per unit, 653 kw. hours would be required (to allow for transformer losses), at a cost of 32s. 8d., for which about 12½ tons of steam could be raised. In this latter case, the steam engine could consume 34½ lb. of steam per horse-power hour. Since steam engines are now constructed that do not consume more than 11 lb. of steam per horse-power hour, including condensation, steam is the more economical in either case.

The following data has been compiled of the cost of sinking by the congelation process in stages. The first estimate is based on a sinking time of 34 months to completion, including a stoppage of six months. Labour is put down at an average of 5s. 6d. per shift. The number of men averages 115, working an aggregate of 106,300 shifts, and 17 men will be required to dismount and despatch the machinery at the end of the work. The time required for the preliminary work of sinking is taken as four months, making a total of 108,000 shifts, costing £29,700.

Estimate I.

	£
A. Refrigerating plant:	
1. Interest and depreciation on capital out outlay of £18,750, spread over four years=38·5%	7,200
2. Refrigerating house and engine foundations, £1,000; depreciation 80%	800
3. Materials for freezing, at £2 per diem, for 28 months	2,100
4. Cooling water, 1,300 gallons per minute	2,340
B. Drilling 32 boreholes:	
1. Foundations for winches and flushing pumps	50
2. Alteration to sinking derrick	50
3. Refrigerating pipes—presumably abandoned—about 120 yards to each hole, at 10s. 6d. per yard	2,000
4. Depreciation on recovered, but damaged freezing, borehole, and down pipes: 60% on £22,000	13,200
5. Securing borehole casing to shaft wall, 10 straps for each set, at 10s. ...	160
6. Depreciation, upkeep, and interest on drilling plant, including requisites...	2,500
Salaries and wages:	
1. Wages	£21,700
2. Salaries: three officials for three years at an average salary of £150 including bonuses, insurance, etc.	2,100
D. Steam consumption at 2s. 7d. per ton	
1. For refrigerating plant tons 62,208	
2. For brine pumps tons 9,072	
3. For the winches and flushing pumps ... ... tons 13,000	
tons 84,880	11,000
E. Tools, light, timber, boring tools, sieves, allowance for men's clothing, etc., at £2½ per yard sunk	2,500
F. Carriage both ways of machinery, tools, etc.	1,500
Total	£98,500

According to this estimate, the cost of sinking in 34 months averages £805 per yard.

The following estimate is based on the sinking taking 40 months, and on the rate of wages per shift being 6s. 1d.—this latter sum being considered more in accordance with the conditions in industrial districts.

Estimate II

	£
A. Refrigerating plant	12,440
Additional materials for the extra six months	420
Extra consumption of cooling water	780
B. Sinking the boreholes	17,000
C. Salaries and wages:	
Wages, 108,000 shifts at 6s. 6d.	35,100
Plus, for the extra six months	7,000
Sunday work, 20 freezers	100
Salaries, 3½ years	6,300
D. Steam consumption, 34 months	11,000
Additional 23,760 tons for the refrigerating plant	3,080
E. Materials for sinking	2,500
F. Carriage, including £150 for the extra six months	1,050
Total	£97,050
(or £970 per yard sunk)	

In neither estimate is any allowance made for profit, nor for any percentage of the cost of the general machinery and appliances concerned in the sinking, such as raising rock, sinking apparatus and engines, derrick, wear of winding ropes, ventilation, drilling machinery, sinking stages, etc., or steam consumption of the sinking engine, stage winch, and fans. The consumption by these machines is approximately equal to that in shaft boring, so that it need not be taken into consideration.

The cost of steam was calculated on a consumption of 13¼ lb. per horse-power hour by the main engine, 77 lb. per horse-power hour by the brine pumps, and 66 lb. per horse power hour by the drilling machinery. Nevertheless, under less favourable conditions, the cost per yard increases very quickly, and may, in exceptional cases, where the sinking takes much more than 40 months, amount to £1,250 and more per yard.

The value of the final tubbing is not included in either estimate. This tubbing is generally introduced in short lengths, and frequently suffers during the subsequent thawing out, which is effected,

almost entirely, by the natural heat of the ground. Artificial thawing, which has proved the only correct method in other cases, is inapplicable with the system under consideration, because the freezing pipes are dismounted on lining the widened portion of the shaft. All that could be done in the matter of artificial thawing would be to assist the natural process from inside the shaft.

Injury to the tubbings is liable to occur during natural thawing, on account of the forces released, and in respect of whose dimensions, direction, and points of application there cannot be anything but surmise beforehand. Moreover, should any considerable injury occur to the tubbing, it is impossible to replace the damaged portion, because the shaft cannot be re-frozen. In extreme cases, a second ring of tubbing must be inserted, inside the first—a proceeding which will reduce the diameter of the shaft to 17 ft. to 18 ft., and at the same time dissipate the only advantage the congelation process has over the boring process, whilst also increasing the cost very largely, the inner cylinder of tubbing being very expensive.

In the most favourable circumstances, the sinking of a shaft more than sinking through dry ground, and the cost is only a few pounds per yard more. On the other hand, in the worst imaginable case, the sinking may turn out a failure after the work has gone on for years at enormous expense. In hand sinking, with an influx of 2,200 gallons (3,300 gallons) per minute, and raising the water in buckets, the time required will take 17 (27) months per 100 yards, and cost about £800 per yard method not practised), as compared with only about £500 (£850) for electric pumping with generated current, and £610 (£1,100) with purchased current. Shaft boring with the Stockfisch or Deutscher Kaiser methods takes 39 months, and costs £350 per yard; whilst carrying out the congelation process in stages takes 34 to 40 months, at a cost of about £800 to £970 per yard, though in specially difficult cases the time may be increased very considerably, and the cost to over £1,200 per yard.

Rules for Sinking Through Very Wet Ground at Great Depth.

1. On approaching a wet zone of unknown water content, this zone should be proved by advance borings.

2. Unless the cementation process is practically sure to be a failure in the wet ground, this process should certainly be given a trial.

3. In the event of failure, an approximate estimate of the influx of water should be obtained by means of the cementation boreholes.

4. If the influx does not exceed about 2,200 gallons per minute, the quickest method of sinking is by baling out the water with bucket apparatus, the higher cost in comparison with boring being small in view of the saving of nearly two years in time, provided generated current is available.

(*a*) If the incoming water is not too highly contaminated, electric pumps alone should be used.

(*b*) In such case, a power house should be erected in good time.

(*c*) Where current has to be purchased, the decisive factor will be whether the two years' saving in time is of sufficient importance to counterbalance the higher cost—some £29,000—as compared with boring.

(*d*) Where the water is very dirty, centrifugal pumps are inadvisable, as the blades are subjected to very rapid wear by sand, and the frequent stoppages for repairs delay the completion of the shaft by many months. Whether, in such event, the saving in time effected argues in favour of baling must be decided from the actual state of the case.

5. When there is a continuous influx of, say, 3,000 gallons per minute, the Stockfisch or Deutscher Kaiser boring method will be decidedly the most economical method, the increased time entailed being immaterial in comparison with the cost of raising this amount of water.

6. Only when the rock is very steeply pitched or very hard, and the water comes in quicker than about 3,000 gallons per minute, should the refrigeration process, by stages, be adopted. If this process be employed, then the following points should be borne in mind :—

(*a*) The lower diameter of the widened portion of the shaft should be large enough to ensure the formation of a sufficiently thick frost wall in the upper part of the wet zone as well; and the widened portion should be of ample length. Given these conditions, the stand pipes can be set at an angle which will ensure the boreholes being not too far away from the shaft in the lower portion of the water zone.

(*b*) The boreholes should be sufficient in number to ensure that a good frost wall will be obtained even if some of the holes turn out unfavourably in point of direction.

(*c*) The refrigerating plant should be of ample capacity for the maintenance of low temperatures.

(*d*) The refrigerating plant should be run so as to maintain the maximum efficiency, for which purpose an abundant supply of cooling water, at the lowest possible temperature, should be available.

(*e*) The sinking must be conducted with the greatest care. The shaft must be lined with tubbings, either temporary or permanent.

Conclusions. — There seems little prospect of effecting improvement, from the economic point of view, in either the pumping method or that of congelation by stages, both having already reached a high stage of technical development. It is therefore improbable that, in either case, sinking can be effected more quickly than has been stated above. Moreover, any further improvement in the total efficiency of the centrifugal pump will not do more than slightly reduce the cost of pumping; nor is any appreciable cheapening of the congelation process to be anticipated. The only point in which any great saving could be wrought about is in reducing the chances of the water breaking through.

On the other hand, the high speed, water flush, percussion method had considerable prospects of development, in both technical and economic respects, and it is therefore probable that the average monthly rate of sinking can be increased to 21 ft. or more in medium hard rock. The adoption of a rod-changing machine would also reduce the number of men required on the boring plant very considerably.

If this method were more frequently employed in shaft sinking through deep wet zones, there would be a greater chance of improvements being introduced on the basis of the experience gained."
—H. Muller, *Glückauf.—Colliery Guardian*, Sept. 28, 1917, p. 593. (E. M. W.)

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THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA

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Vol. XIX AUGUST 1918. No. 2

THE MANUFACTURE OF CRUDE SODIUM MANGANATE FOR USE ON THE MINES.

By F. WARTENWEILER (Member of Council)

(Printed in Journal, January, 1918.)

REPLY TO DISCUSSION.

Mr. F. Wartenweiler *(Member of Council).* Replying to queries by Mr. F. W. Watson:—The cost of the manganate has varied considerably with the change in the price of the raw materials, pyrolusite and caustic soda. Of these, the latter has been advancing at such a rapid rate that it is difficult to state the cost of manufacture. Having the ratio of raw materials before him (one part by weight of 40% Mn ore to 1·44 parts caustic soda) and their price, the reader can, however, approximate the cost of the manganate, as the labour and fuel charges involved are comparatively small. The 40% Mn ore used is pyrolusite of 63·28% MnO_2 content. The caustic soda (commercial 98-99%) contains 91·3% NaOH. The use of quicklime and sodium carbonate, as suggested, in the place of caustic soda, was unsuccessfully experimented with. The limited time at our disposal for such experiments did not permit extensive investigation.

Mr. John Watson's reference to the early use of manganate in oxidising London sewage in the river Thames is of considerable interest. In the analysis of caustic soda given by him, the 93·3% NaOH content agrees roughly with that of the caustic soda used.

Mr. Galbreath was engaged in our early trials on the sodium manganate manufacture, and the method of analysis suggested by him is the result of experience.

Further experience in manufacture has brought forth no important development since the paper was written. The necessity of giving the reaction sufficient time has been regularly confirmed. The interposition of a sheet of paper between the hearth of the furnace and the charge, has been of practical advantage in preventing the "freezing" of the manganate to the brick of the hearth.

THE ESTIMATION OF INJURIOUS DUST IN MINE AIR BY THE KOTZE KONIMETER.

By JOHN INNES (Associate).

(Printed in Journal, March, 1918.)

DISCUSSION.

Dr. J. Moir *(Past-President).* The question raised by Mr. E. M. Weston as to what is the limit of size in dust beyond which it becomes innocuous is so important that I feel I must intervene before the discussion closes. I think that Mr. Weston has been misled in his reading of the three paragraphs from the Prevention Committee's Report, which he quotes on p. 304 of the June *Journal*. Of these three the middle one, appendix 8, appears at first glance to be inconsistent with the other two, but the fact is that it is not so, for the use of polarised light on sections mounted in balsam renders at least 99% of the particles *invisible*. Consequently Pitchford's observation of 18% of particles over eight microns, when duly corrected for the invisible silica, comes down to less than 0·1%, and the three independent observations of McCrae, Pitchford and Moir are all in prac-

[illegible] agreement. This proportion of largish particles in my opinion is insignificant as a practical causal factor in the disease, and therefore Mr. Innes is quite justified in calling the opposite view an "academic" one. I wish also to protest against Mr. Weston's surmise that the lung which I examined was abnormal in regard to dust contents. It gave as a matter of fact much the same results as Dr. McCrae got from a different specimen several years earlier, viz., about 50% of the particles were of 1 micron or less diameter, 90% were of 2 microns or less diameter, 99% were of 4 microns or less diameter, and 99·95% were of diameter less than 8 microns. It therefore passes my comprehension how Mr. Weston can ascribe any effect to the balance of 0·05%, which is larger than 8 microns, especially when he is unable to produce any positive evidence that such larger particles ever escape the protective devices of the body and enter the lungs proper in any number. Mr. Weston does not seem to realise that Pitchford and I examined the lungs not only of those who *died* of miner's phthisis, but also of some who died of accident, and therefore had no time to get rid of his supposed excess of larger particles by nature's methods, and that there was no more than 0·05% of such particles even in "early silicosis."* I begin to wonder whether Mr. Weston realises what a very small fraction 0·05% is—does he realise that he could put 0·05% of arsenic or cyanide in his sugar and yet survive, as this would mean about 1/20 gr. for every ¼ oz. of sugar.

Finally, I wish to make it quite clear that I do not assert that dust between 5 and 10 microns diameter is harmless; what I think is that dust *above* 10 or 12 microns is really harmless, and that dust between 5 and 10 microns is harmful, but is not worth considering in view of its low proportion in mine air; and to say that it is "not worth considering" is much the same as saying that it is "academic."

I may say also that I think Mr. Weston has encountered another fallacy when he infers (p. 274) that with a small variability of the proportion of "dangerous" dust Mr. Innes is wrong in thinking the gravimetric method useless. I myself also consider the Chamber of Mines' gravimetric method nearly useless, but this is because their gravimetric method catches really large particles up to nearly 50 microns in diameter, of which 10 weigh as much as 1,000,000 of the 1 micron particles. If the Chamber of Mines would adopt a gravimetric method which would eliminate everything above 10 microns, *then* I should consider their results to be as good as those of the konimeter.

* Watkins Pitchford & Moir: Bulletin No. 7 of the *S. A. Institute of Medical Research*, 1916.

ASSAY SUPPLIES AND THE UTILISATION OF SOUTH AFRICAN MATERIALS IN ASSAY OFFICES.

DISCUSSION.

Mr. T. Graham Martyn *(Member)*: I wish to relate in this contribution my experiences and conclusions on the subject under discussion.

Cupels.—I only ventured recently to try cement bottoms for cupels, as I was told a good while ago that they were not altogether a success, and did not care to disturb the office routine by trying something not too well reported on by others, besides being rather dubious as to their capacity for absorbing a normal amount of lead. A few months since, however, our consulting metallurgist requested that a trial be made, and I may say at once I think the result is quite satisfactory. It did not call for any serious change in the method of manufacture, as we have for some years past been giving the mould a second filling as otherwise our cupels were too shallow.

The machine used is Braun's table pattern with automatic feed hopper, and in order to make the compound cupel the hopper is filled with suitably moistened cement and a tin of moistened cupellite is placed on the left of the operator, who rotates the disc sufficiently to bring a mould full of cement under the plunger, presses it moderately, raises the plunger, fills the top of the mould with cupellite, and after pressing as hard as possible ejects the cupel as usual. It will be noted that we get the smooth pressed surface between the cement and the cupellite which Mr. Watson seems to have found a source of trouble, but the cupels are quite satisfactory and the economy achieved is very considerable. These cupels are cylindrical, and the cupellite is pressed straight down on the partially pressed cement; it is quite possible that when making cupels of the partially conical form in two stages of

pressure there would be inequalities in the distribution of the pressure that would lead to unequal shrinkage in drying and to drawing around the edges as described by Mr. Watson.

Crucibles. My experience with local crucibles has not been such as to justify me in supporting the statement that they are better than the ones formerly imported from England and Germany, in fact I think the "Three Star" crucibles were the most resistant to temperature, change and gold assay slag erosion that I ever tested and were very closely run by the Battersea pots. If our local manufacturers could only manage to imitate them more closely in the physical texture of the mixture employed they would achieve even better results than they have up to the present. Until recently at any rate, local makes have shown a tendency to sudden changes in quality, which have at times been very annoying; but I have found the greatest uniformity and obtained the most satisfactory results from a brand, which, whilst made I judge from a clay of inferior quality to that employed by other makers and so weak physically that the pots will scarcely stand carriage, and the boys at first can scarcely get them in and out of the furnace without breaking the edges, yet, owing to the coarser texture and more even mixing and moulding, last longer on the average than the more finely ground and stronger pots. Pots of a fine-grained and very hard-burnt type I have found the most disappointing of all, frequently eating away at the bottom in deep gashes and becoming too threatening for further use after only two or three fusions.

We get an average of from twelve to fourteen fusions from No. 2 pots, but by trying a pot over and over again until it failed I have obtained as many as thirty-six fusions from a "Three Star" and nearly as many from local makes. Possibly one could get an average of eighteen or more fusions per pot if a pot were never rejected until it absolutely failed, but one prefers naturally to reject a pot that looks pretty bad rather than run the risk of numerous repeat assays. Seven years ago, when pots were almost all imported from overseas, questions of economy did not loom so large in our minds, and we were less inclined to take risks for the sake of saving a little in costs, hence when a pot had done service for four or five times and began to show a little corrosion at any point we used to help make bricks for the back of somebody's garden, but when local pots were offered and destructive trials invited, we discovered that pots which after three or four fusions looked about finished were good for another ten or a dozen repeats. At about the same time some of us drew attention to the destructive effect on pots of slags rich in borax, and the latter has probably of recent years been used much more sparingly with corresponding advantage to the average life of crucibles. Again, the pots get much less severe testing in the reverberatory furnaces now so generally employed than they used to get when bedded in the fuel of the old Cornish furnaces. I doubt if local pots would stand an average of half a dozen fusions in a *coke* fired Cornish furnace.

I have written somewhat at length on this subject lest the local manufacturers should not be tempted by the testimony already printed in our *Journal* to rest on their oars and relinquish their efforts to produce with certainty and regularity a pot really equal to the "Three Star" and "Battersea" pots; otherwise should the latter ever have a chance of competing *in price* they will certainly regain a considerable footing in the district.

Borax Substitute.—The substitution of fluorspar for borax in assay practice has also proved to be both a technical and an economic success; and as I do not know who originally suggested it, I can without bias express the opinion that he, as well as the originator of cement bottoms for cupels, ought to be granted a substantial reward by the mining houses.

When asked to make a trial of "fluxite," having been assured that others were using it successfully, I decided as a first experiment to replace the whole of the borax by the same weight of fluxite, and found the resulting slag as fluid as usual and, if anything, easier to separate from the lead button. After a few days, however, I noticed that crucibles were being used up at a great rate, but for the moment forgot the change of flux and blamed the manufacturers of the crucibles for one of the all too frequent fluctuations in quality. An inspection of some of the rejected pots, however, showed that they were very uniformly corroded, and it then dawned on me that I had not given sufficient consideration to the possible effect of the fluxite in

modifying the acidity of the charge. The removal of the borax would certainly leave the flux more basic, and the question arose would the fluorspar be neutral or would its use also tend in the same direction? Text books have told us that fluorspar improves the fluidity of charges simply by admixture owing to its own greater fusibility, but I long since discarded that explanation as experiments with fluorspar alone showed that it was by no means easily fusible, and it is much more likely that it combines to form fluo-silicates of greater fusibility than fluorspar itself. Now, a fluo-silicate contains a metallic fluoride such as fluorspar (CaF_2) itself, combined with silicon tetra-fluoride (SiF_4). In the production of the latter silica (SiO_2) must be used up, thereby increasing the basic character of the charge and the liberated oxygen replacing the fluorine will produce calcium oxide (CaO) and thus act further in the same direction.

The kind of action which I believe takes place may be represented thus:—The equation $2CaF_2 + SiO_2 = SiF_4 + 2CaO$ sets forth the simple exchange between fluorspar and silica for the sake of clearness, but to each side must be added $CaF_2 + 2SiO_2$, giving the result

$$3CaF_2 + 3SiO_2 = CaSiF_6 + 2CaSiO_3.$$

Here then we have the probable explanation of the corrosion of crucibles and liners, we have removed the acidic flux borax and replaced it by the basic flux fluorspar. This also explains the boiling over complained of, as some of the carbonate of soda, instead of being decomposed gradually by contact with the free silica in the charge during the progress of the fusion (before actual fusion and whilst the charge is still somewhat open and porous as is normally the case) some of the carbonate of soda I repeat remains when the charge reactions are completed and reacting with the silica of the crucible itself corrodes it badly and keeps up the evolution of carbon dioxide with consequent boiling over of the charge.

The remedy in the case of our assay charges, where the gangue is mainly silica, is obviously to reduce the amount of flux employed. This I did by about 10% with immediate and complete success, thereby saving in the soda carbonate and litharge more than the cost of the fluxite employed and, of course, saving in addition the whole cost of the borax formerly used.

To intrude for a moment on the domain of the cyanider, I have been told that the attempt to use fluorspar in the smelting of gold zinc slime has not been a practical success mainly owing to rapid corrosion of the liners. This case is a little different, as the gangue is rather on the basic side and in some cases at any rate calls for the addition of silica.

My suggestion for a further trial is as follows:—Take any borax mixture which is normally successful for the particular sample of gold zinc slime and omitting *all* the fused borax, replace each unit of the same by 0·3 units of silica (sand residue) or, say, one-third. Try in successive experiments varying proportions of fluorspar or fluxite, but always using in addition for each unit of fluorspar a further 0·77 units of silica or, say, three-quarters. If the corrosion of the liner is not overcome by the foregoing formula a larger proportion of sand should be tried.

Litharge.—A certain amount of silver-free litharge is essential unless we are to be driven to the expedient of parting all our assays, and incidentally doubling the European staff. If litharge could be produced locally containing silver in moderate amount and *evenly distributed*, one could determine its amount in a normal charge of flux by running a blank on pure silica and then deduct this amount from every assay bead before taking off the usual 10 + for silver in the bullion; but I have too often found that when litharge carries more than a trace of silver the amount is distributed very irregularly, making the above procedure impracticable. As it is quite unnecessary to use silver-free litharge when the beads are to be parted before weighing, care should be taken that the small amount of such litharge that is available should be fairly distributed amongst the mines, and should only be used when really necessary.

One rather hesitates to use commercial litharge, fearing the presence of impurities variable both as to nature and amount, such as barytes, zinc oxide, etc., which in small amounts would affect the fluxing of the charges and might call for an alteration of one's flux mixture every time a new batch was purchased.

Referring to Mr. Toombs' remarks on using litharge as a flux, I certainly think it desirable to allow a little for the slag, and his presumption that a 40 gm. button would be aimed at from a 5 A.T. charge points to an attempt at economising in cupels and in muffle space at the expense of a reasonable allowance for the lead

button. Bermger taught us to aim at 300 gm. to 40 gm. for a 50 gm. charge, and I am quite satisfied from my 25 years' experience that 20 gm. is *dangerously low* for a 2 A.T. (or, roughly, 60 gm.) charge. The 5 A.T. charge I take to be for the assay of a slime residue, and since we are now-a-days anxious to show up every trace of gold that is possible it seems to me that a 60 gm. lead would be quite small enough to aim at with, say, 50 gm. for the danger limit. Personally, I aim at 50 gm. to 60 gm. for a 4 A.T. residue, the flux mixture weighing about 10 A.T., and in the ratio of six parts by weight of soda carbonate, four parts litharge and one part fluxite. This gives about 106 gm. litharge, of which about 66 gm. is used up for the lead button, leaving 40 gm. to enter the slag. This could be replaced by 20 gm. of soda carbonate, but at the expense of the fluidity of the slag or else a considerably higher temperature, prolonged fusion and more rapid wastage of crucibles and furnace linings.

For the other surface samples with 2 A.T. charges I use about 5 A.T. of the same flux mixture but aim at a proportionately larger lead, and thus leave very little litharge in the slag. For mine samples, however, I use a mixture of equal parts of soda carbonate and litharge and one-eleventh of fluxite as before, thus allowing a wider margin for errors of judgment in adding flour or nitre, getting a heavier button instead of a hard and sulphury one if too much flour or insufficient nitre has been added.

Cuprous Chloride Solution.—In making up the cuprous solution we have, for the past seven years at the New Unified, been using *commercial* hydrochloric acid and common salt as supplied to the compound. This necessitates filtering, but as the commercial sulphate of copper and sodium sulphite seldom give a clear solution it is advisable to filter in any case. The sodium sulphite is dissolved in the minimum of hot water and filtered separately, then cooled and mixed cautiously with the acid solution of copper sulphate and common salt.

We have not yet tried Mr. Toombs' suggestion, to use copper sulphate, hydrochloric acid and scrap copper wire only, and should be glad of a statement from him of the quantities employed. I am surprised at the inference that the cuprous chloride can be retained in solution without the aid of common salt.

Nitric Acid.—Would it not be feasible for the Rand Co-operative Smelting Works to procure from Vereeniging a suitable earthenware still and condenser, collect our weak acid residues, diluted probably to about 1 : 5 at most (care being taken to keep the water wash out of the acid residue jar), distil off the excess water containing, of course, a little of the acid and re-sell to the mines the distillate of constant composition the purity of which could be guaranteed if care were taken on the mines to leave a little silver behind in the acid, avoiding that is the addition of any trace in excess of the chloride used in precipitation. A portion of the weak distillate coming over at first could be used for washing out the residual silver nitrate from the still, these washings being tested (after removal of the silver as chloride) for the possible presence in remunerative quantities of platinum and palladium. Commercial nitric acid might be used as "make up," and all the requirements of the assay offices be met by the reduction works. A motor lorry fitted up with glass carboys might be employed to traverse the Reef, east and west alternately to collect and deliver the acid. It is certainly a pity that such an expensive article should be wasted as it is at present.

Sodium Carbonate.—The first samples of the local carbonate of soda which were submitted to me contained a rather large proportion of free carbonaceous matter which gave us very large leads, a fault easily compensated for in samples which call for the addition of flour, but very objectionable in the case of pyritic samples which call for nitre as it is always desirable to keep the latter down as much as possible owing to its tendency to make the charges boil over. I pointed out that almost all this impurity could be removed by redissolving the soda ash, filtering through a rough and ready filter, re-evaporating and calcining; and that a little higher price could be borne, if needed, to pay for the extra treatment. I do not know if anything has been done by the producers, but as we have only a very small proportion of pyritic samples we have been using this material without inconvenience for some time past.

Fuel.—A little economy I effected some six years ago may be worth recording. By keeping an extra muffle door in use I do all the parting without any cost for heat either with primus or other burner or electric heater. A muffle door showing a good red heat over, say, half its inner surface is

replaced by the spare one and carried into the pickling room, lid cooler side down on a suitable non-conducting support and propped up, if necessary, so that the hot side or top is level. A frying-pan, preferably of aluminium, is placed on it and the porcelain crucibles as the 1 : 2 nitric acid is poured into them are placed one after the other in a spiral thereon, commencing on the margin and proceeding in clockwise direction towards the centre. A few moments' pause after the crucibles are filled and in situ suffices for heating the acid and beads are flattened and transferred to them in due order. When the brick is a bit too hot and the action becomes violent the frying-pan is lifted for a moment and three little pieces of asbestos board placed on the brick to keep the frying-pan from contact with the hot surface. The handle of the frying-pan should be cut to a length of about 5 in. and have some asbestos cord wound round it and made secure so that it can be easily handled. When the acid treatment is considered sufficient, distilled water is run in preferably by syphoning over from a Winchester quart bottle placed on an adjacent shelf. The slightly cooled and diluted acid is poured off; the empty crucibles being placed in turn on the working bench preferably on a square of asbestos board in the same spiral fashion. Wash water is run on and again poured off and the empty crucibles replaced on the frying-pan, covered with a large filter paper and left about five minutes to dry, then transferred to an annealing tray and annealed in a suitable muffle, preferably one reserved for this work, heated to a fair red and having the lift at the back closed to avoid drawing dust-laden air over the crucibles.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

A Rapid Method for the Determination of Lime as Calcium Sulphate.—"After precipitating as CaC_2O_4, ignite in a crucible, mix the residue with a fusion mixture composed of equal parts $(NH_4)_2SO_4$ and NH_4Cl, heat to change the lime to $CaSO_4$, volatilize excess salts and weigh as $CaSO_4$. Perfected details given are said to supply results highly satisfactory, especially for large amounts of Ca."—L. G. Willis and W. H. McIntire, *J. Ind. Eng. Chem.*, 9, 1114-6 (1917). *Chemical Abstract*, January 10, 1918, p. 29. (J. G.)

The Analysis of Zinc.—"Details of a quick method for the analysis of Zn alloys. Dissolve in concentrated HNO_3, evaporate to one-third original volume, then drop H_2SO_4 into the centre of the liquid, and heat until white fumes are given off. Add H_2O and EtOH and allow to stand several hours until $PbSO_4$ has settled. Ignite the precipitate in a crucible which has just been heated with a drop of H_2SO_4. Precipitate Cu as sulphide and heat with S in H_2 using a silica crucible. Precipitate Al and Fe from the filtrate after removing H_2S, by adding H_2O_2, and then quickly a large excess of NH_4OH. Fe is estimated volumetrically in a separate portion."—Mossbacher, *Z. offentl. Chem.*, 23, 113-5 (1917); *J. Chem. Soc. Abs.*, II., 389.—*Chemical Abstracts*, January 20, 1918, p. 125. (J. G.)

Wood Distillation.—"The hard woods and the soft woods give differing results after distillation. The first give low yields of black, viscous, ill-smelling tar but high yields of acetic acid and wood spirit (methyl alcohol). Two typical woods may be taken for example, the one hard the other soft, and their distillation products compared.

	Oak Wood. Per cent.	Pine Wood. Per cent.
Acetic acid	4·4	2·2
Equivalent to acetate of lime...	5·8	2·9
Methyl alcohol	1·1	0·6
Tar, separated	6·4	12·9
Charcoal	25	29

The crude acid when redistilled and neutralised with lime produces grey acetate of lime the value of which is at present £36 per ton, whereas before the war it was only £8 per ton. There is a large demand for it for the extraction of acetone. Some of it is manufactured in Ceylon and the Imperial Institute, on behalf of the Home Government, is enquiring if any of it is available for export. Acetone is required in large quantities for the manufacture of propellant explosives. Acetic acid is produced in large quantities in Ceylon and used in the preparation of rubber. Cocoanut shells when distilled give a good yield of acetic acid and produce also creosote required for the preparation of smoked rubber. There is also a timber known as Vera wood growing in the dry zone of Ceylon from which is distilled crude acetic acid liquor, charcoal and tar, in fair quantities. By redistilling the crude liquor, after the addition of fresh charcoal, a pale yellow, clear solution of acetic acid is produced. Methyl alcohol is the chief constituent of the commercial product known as wood alcohol or wood spirit, which includes some acetone, esters and other products. The value of this product in July, 1914, was 2s. 7d. per gallon but at the close of 1916 had risen to 5s. 6d. It has already been stated that the distillation products of hard woods and of soft woods differ somewhat. In considering tar it must be noted that hard wood tars cannot be used for treating ropes and twine. Soft wood tars, on the contrary, such as those obtained from pines and coming on the market under the name of Baltic and Stockholm tars, are the ones suited for this purpose. There is, in fact, not much scope for the use of hard wood tars except in the way of fuel. Black wattle wood and olive wood were experimented on at the Imperial Institute, London, being obtained from the East Africa Protectorate, with the following results :—

	Acetate of Lime	Wood Spirit	Tar	Charcoal
Oak wood—				
Yield per ton ..	112 lb.	3 gal.	100 lb.	580 lb.
Value of yield, June, 1914	8s.	8s. 4½d.	1s. 9d. 2s. 3d.	14s. 10d.
" " Dec., 1916	£1 16s.	17s. 10½d.		
Black Wattle Wood—				
Yield per ton	139 lb.	3·7 gal.	134 lb.	695 lb.
Value of yield, June, 1914	9s. 11d.	9s. 1d.	2s. 4d. 3s.	15s. 6d.
" " Dec., 1916	£2 4s. 10d.	£1 0s. 4d.		
Olive Wood—				
Yield per ton ..	90 lb.	5 gal.	106 lb.	650 lb.
Value of yield, June, 1914	6s. 5d.	12s. 9d.	2s. 11d. 3s. 8d.	16s. 8d.
" " Dec., 1916	£1 8s. 1d.	£1 7s. 6d.		

It will be seen that, taking the prices obtainable in June, 1914, which may be regarded as normal, both wattle wood and olive wood show a slight advantage over oak wood, and should therefore be at least as profitable to distil.

Practically the whole of the imports of the products of wood distillation are retained in the United Kingdom; further, the only country of the Empire which supplies the United Kingdom with any of these products is Canada."—*Indian Engineering*, Feb. 2, 1918, p. 68. (J. A. W.)

STELLITE AS A SUBSTITUTE FOR PLATINUM.—"Owing to the great scarcity of platinum and its consequent high price, platinum substitutes have been eagerly sought, particularly within the last three or four years. From what has already been accomplished in this direction it is evident that no single metal or combination of metals will fully take the place of platinum. The alloy of gold with palladium affords a partial substitute for crucibles and dishes, and perhaps more nearly replaces platinum in this respect than anything yet offered. The price of this alloy, however, is comparatively high, though, bulk for bulk, it is only about half as costly as platinum. The alloy of nickel with chromium, the silicon-iron alloys, and pure quartz have also given satisfactory results for certain laboratory purposes.

The stellite alloys are not fixed or definite in their composition, but may be divided broadly into two classes: (1) those malleable at red heat, and (2) those that can be worked into the desired form only by casting. The malleable alloys are composed almost entirely of cobalt and chromium, and the proportion may vary from 10 to 30% of chromium, with a corresponding variation of the other constituent. These alloys are very hard and almost perfectly non-corrodible, [illegible] of the [illegible]. They forge with difficulty at temperatures ranging from 800 to 1,200°. They have been forged into [illegible], surgical instruments and jewelry.

The unmalleable alloys are not easily attacked by either hydrochloric, sulphuric, or hydrofluoric acid, and are so nearly immune to all chemical reactions [illegible] as well as to the [illegible]. A comparatively [illegible] a bright polish and can be made of comparatively light weight [illegible] will prove suitable for evaporating many chemicals [illegible] and particularly suitable for [illegible]. Substitutes [illegible] to these [illegible] brittleness, since the tensile strength of the alloy [illegible] pounds per square inch. The [illegible] retain their lustre under practically all [illegible] conditions. The [illegible] give most excellent results in the form of lamp [illegible], triangles, etc. They can be heated to full redness without the formation of scale, and subjected to temperatures up to 1,200° C., and still retain considerable strength. In fact, the stellite alloys possess the highest "red hardness" of any of the alloys yet discovered.

In many cases stellite may be substituted to some advantage for platinum in jewellery. It is almost of the same colour, possesses a higher lustre, and retains its lustre very much better than platinum, since it is so hard that it is not scratched or abraded by ordinary use. While not nearly so pliable as platinum, it can be worked into many forms of jewellery without special difficulty."—E. HAYNES—*Journal of Franklin Inst.* (*Journal of Ind. and Eng. Chem.*), Jan., 1918, p. 151. (J. W.)

METALLURGY

AMMONIA LEACHING OF COPPER TAILINGS.—"Up to date a large proportion of the milling ore has been mined from the [illegible] fissures. Table I. gives an idea of the character of the ore:

TABLE I.—*Average Analysis of Bonanza and Jumbo Ore.*

Chemical Analysis.

	Per cent.
Cu*	7·99
CaO	36·76
MgO	10·1
Al_2O_3	0·15
Fe	0·47
S	1·55
Insoluble	0·70
CO_2	41·15
H_2O	1·08
O	0·19
	100·47

*2·73 Cu in carbonate form.

Mineralogical Analysis.

	Per cent.
Chalcocite, Cu_2S	5·50
Covellite, CuS	1·23
Bornite, Cu_5FeS_4	0·13
Malachite, $CuCO_3 \cdot Cu(OH)_2$	4·75
Dolomite, $CaMg(CO_3)_2$	87·37
Hematite, Fe_2O_3	0·64
Miscellaneous Al_2O_3 insoluble	0·85
	100·47

Metallurgically, the ore may be looked upon as consisting of chalcocite and its oxidation products, malachite and azurite, in a gangue of gray limestone and dolomite. Covellite and enargite are found occasionally, and chalcopyrite and bornite are present in minute amounts with the other sulphides. The chalcocite occurs chiefly in seams and bunches in the limestone, permitting easy recovery by coarse crushing and water concentration. A small proportion of the chalcocite occurs intergrown with calcite, and requires fine crushing to liberate the sulphide. The occurrence of the other copper sulphides is similar to that of chalcocite, and in the absence of any heavy gangue mineral these offer no difficulty in concentration.

Malachite and azurite are found throughout the mines as oxidation products of the copper sulphides. The proportion of carbonate ore varies from 10% to 90% of the total copper value and for the ore developed to date has averaged 36%. A general decrease in the proportion of carbonate occurs with depth, although where intense fracturing has permitted free water circulation, the proportion of carbonate is as high as it is near the surface. The vertical ore bodies, as a rule, contain a much greater proportion of carbonate ore than either the flat or intersection bodies. The rich chalcocite body of the Bonanza outcrop is of the intersection type, so the condition arises of slight oxidation on the surface in comparison with that found in the open vertical fissures at a depth of 900 ft. in the Bonanza mine.

Calcite occurs with the ore minerals in small amounts and, with limestone and dolomite, forms the gangue. The limestone and dolomite occurring in the ore bodies are slightly iron-stained near the surface, but otherwise are generally fresh and unaltered, even in the centre of wide ore bodies.

Mining and Milling Methods. In the mill the ore is broken to about 4 in. size and hand-sorted to separate large pieces of sulphide and carbonate minerals from the leaner material. The remainder is then further crushed for concentration on jigs and tables. The coarse-crushing system consists of Blake-type jaw and Symons disc crushers with finer grinding in Traylor rolls. Coarse concentration on bull, Harz and Hancock jigs is followed by further treatment on Wilfley and James sand tables and James slimers. Sliming is avoided as much as possible, since the carbonate contents of the slime are recoverable with difficulty except in a product too low for profitable shipment. Ninety-five to ninety-six per cent. of the sulphide and about 60% of the carbonate values are recovered in the mill. Part of the tailing is re-treated in the leaching plant, and the remainder stored for future handling.

The reasons for experimenting with leaching, rather than sulphide-filming and flotation as a further treatment of the mill tailing, were primarily the difference in the concentration ratio with the consequent difference in freight and treatment charges. By using sulphide-filming and flotation a concentrate greatly in excess of 30% Cu could not be expected, while the precipitates from ammonia leaching approximate 70% Cu. Alaskan freight rates, both rail and boat, are high, and the saving of 70% product over 30% product is more marked there than would be the case in a more accessible district.

The first experiments with ammonia leaching were conducted by the testing plant of the Federal Lead Co. in Flat River, Mo., in the winter of 1913-14. These tests were purely of a laboratory character, and no attempts were made to prevent the loss of ammonia. However, it was apparent that Kennecott ore would lend itself to ammonia leaching, as a satisfactory recovery was obtained. Consequently a small experimental plant, consisting of a leaching vat, still, condenser, and storage vats, all of the simplest character, but designed to be ammonia-tight and to give results somewhat comparable to those obtainable under actual operating conditions, was erected in the summer of 1914.

The experimental leaching vat provided for a leaching column of 5 ft., and ordinarily 1 ton charges were leached. The ammonia still, or, more properly, evaporator used direct heat in the form of live steam to distill off the ammonia and precipitate the copper from the copper-ammonia liquors, though occasionally, in an endeavour to diminish the volume of the waste solutions, indirect heat was used.

From the series of experiments conducted, it was concluded (1) that, with a heads assay of 1·2% carbonate copper, an extraction of 75% of the carbonate contents might be expected; (2) that, since the use of water to wash the tailing would prove impracticable, due to the fact that the volume of solution would be large and that therefore the amount of solution to be distilled would prove excessive, a steam wash would be economical in point of time, amount of NH_3 recovered, ultimate volume of solution to be distilled, and amount of steam consumed in the entire process. It was estimated that 100 lb. of steam per ton leached would be sufficient to wash the tailing to a point such that the ammonia retained in the residues would not exceed 0·25 lb. per ton leached; (3) that in the distillation of copper-ammonia liquors the steam used would not be more than 400 lb. per ton leached, the ammonia loss would not exceed 0·25 lb. per ton leached, of which amount the greater portion would be in a waste liquor or boiled-out solution assaying at a maximum 0·03% NH_3, and that precipitates assaying 70% Cu would be produced; (4) that other ammonia losses need not exceed 0·25 lb. per ton leached or a total ammonia loss of 0·75 lb. per ton leached.

Description of 300-Ton Plant.—In view of the results obtained with the experimental apparatus, a plant to have a daily capacity of 300 tons was erected. The leaching vats, four in number and 30 ft. in diameter, with a leaching column 15 ft. high, were designed with a dome-top capable of withstanding a vapour pressure of 10 lb. They each have a capacity of 500 tons of mill tailing per charge. Before they are charged, the tailing is dewatered and partially deslimed. Were the material to be treated an oxide ore, such that dry crushing could be used in preparation for leaching, slime in reasonable amounts could be satisfactorily treated as there would be less tendency for it to segregate and interfere with the leaching and washing of the charges. For charging the vats a revolving plate was provided to distribute the feed evenly over the whole area and to give a uniform mixture of coarse and fine material. After washing, the tailing is removed from the vat by a mechanical excavator through the bottom doors to a belt conveyor which carries them to the dump.

The distillation apparatus installed was of the continuous type. It consisted of an evaporator equipped with two salt filters, and surmounted by a standard ammonia concentrator or still. Connected

with the top of the still was the usual condensing and absorbing system common to ammonia distillation. The distillation apparatus was designed to distill 100 tons per 24 hours of a solution assaying 6% NH_3, and to yield a waste solution containing not more than 0·02% NH_3. The above volume of solution was considered to be the maximum that would have to be distilled from the leaching of 300 tons of mill tailing containing 1·2% carbonate copper.

In March, 1916, operation commenced. From the first the expectations of a satisfactory extraction of the carbonate copper have been fully realised. Also the recovery of ammonia from the leached tailing, about which some uncertainty was felt, has proved to be as complete as the early experiments indicated. On the other hand, difficulties only partially foreseen were encountered in the distillation of the rich copper-ammonia liquors. Before operations had commenced the possibility of precipitates clogging up sections of the ammonia concentrator had been considered, but serious trouble was not anticipated as ammonia stills using lime to break up stable ammonia salts are regularly operated. Clogging, however, of precipitates in sections of the mill occurred as soon as distillation commenced, accompanied by incrustations of a mixture of copper oxide and carbonate upon the walls and steam chest of the evaporator. This proved so serious that single-stage, continuous distillation was replaced by a two-stage process, wherein the primary operation reduced the rich solution from 4% Cu and 7·5% NH_3 to a filtrate assaying 0·1% Cu and 0·9% NH_3. This filtrate was then retreated in a secondary operation to precipitate the balance of the copper and reproduce a waste solution assaying 0·025% NH_3.

After the plant had been in operation for some months, experiments with the idea of simplifying the distillation and securing an economy in steam consumption led to the installation of an evaporator of the periodic type. It is simpler in operation and, as no incrustation takes place on the walls or heating coils in the boiling chamber, its use avoids the frequent cleaning periods of the continuous system. Furthermore, the precipitates produced are of a higher copper content, and a considerable steam economy has been effected.

Absorption of CO_2 by Leaching Solution.—The original lixiviant solutions contained little CO_2, as all ammonia was purchased in the form of aqua ammonia or ammonium hydrate, but, due to the absorption of CO_2, they soon became practically aqueous solutions of ammonium carbonate. The only objection thus far advanced to the presence of CO_2 is the slight increase in time necessary to secure a satisfactory extraction of the carbonate copper. To remove the large amount of CO_2 evolved from the circulating solution it has been found necessary to leave vents open in the top of the vat. The high leaching column has proved satisfactory, though 15 ft. is somewhat greater than is ordinarily used in leaching processes.

As a result of a great deal of experimenting during the first months of operation, the following cycle has gradually been evolved and is the most satisfactory system tried up to the present.

Charging and Leaching.—The dewatered and partially deslimed mill tailing is run into the vat by means of a chain drag conveyor, which extends from the dewaterers over the top of the vats. While charging, the drains are left open in the bottom of the vat, allowing the water that enters with the tails to filter through and escape. The leaching solution is pumped into the vat at the bottom, and rises through the charge, completely covering it. This solution contains enough concentrated ammonia from the stills or from the ammonia storage vats to dissolve the copper contained in the charge, and is diluted or mixed with enough rich copper ammonia solution from a previous leach to give the mixture sufficient volume to cover the charge. In this case, the rich copper ammonia solution acts merely as a vehicle for the "available" or uncombined ammonia and ammonium carbonate, and is not itself a solvent. Its use enables the charge to be covered without introducing an excessive amount of ammonia, or any fresh water to the vat, and keeps the distilling solution rich in copper.

TABLE II.—*Screen Tests and Copper Contents of Heads and Tails of Ammonia Leaching Plant*

In any leaching process there is a shrinkage in the size of the particles during the leaching period, which is evident in the increased weights of the finer sizes in the tails.

Heads.

Size.	% Wt.	% Carb. Cu	Lb. Carb. Cu in 100 Lb. of Sample.	% Total.	Canadaline
On 12 mm.	10·8	0·89	0·0958	9·0	
On 9 mm.	21·6	0·96	0·2069	19·5	28·5
On 6 mm.	28·7	1·01	0·2978	28·1	56·6
On 2 mm.	26·9	1·10	0·2958	27·1	84·5
On 1 mm.	4·1	1·01	0·0456	4·3	88·8
On 40 mesh	2·8	1·36	0·0382	3·6	92·4
On 60 mesh	1·4	1·76	0·0246	2·3	94·7
On 100 mesh	1·3	1·48	0·0192	1·8	96·5
On 150 mesh	0·5	1·69	0·0085	0·8	97·3
On 200 mesh	0·5	1·39	0·0069	0·6	97·9
On 200 mesh	1·1	2·01	0·0225	2·1	100·0
Totals ...	100·0	...	1·0618	100·0	...

Tails.

Size.	% Wt.	% Carb. Cu	Lb. Carb. Cu in 100 Lb. of Sample	% Total.	Canadaline
On 12 mm.	7·8	0·28	0·0218	9·0	6·6
On 9 mm.	18·5	0·23	0·0426	17·5	26·5
On 6 mm.	26·0	0·22	0·0572	23·6	50·1
On 2 mm.	29·9	0·19	0·0568	23·3	73·4
On 1 mm.	5·8	0·25	0·0145	6·0	79·4
On 40 mesh	4·4	0·33	0·0145	6·0	85·4
On 60 mesh	2·1	0·35	0·0071	3·1	88·5
On 100 mesh	2·3	0·36	0·0083	3·4	91·9
On 150 mesh	0·9	0·39	0·0035	1·4	93·3
On 200 mesh	0·9	0·41	0·0037	1·5	94·8
On 200 mesh	1·4	0·89	0·0125	5·2	100·0
Totals	100·0		0·2428	100·0	

	H	H +
Canadaline	68·6	77·1
	76·1	78·9
	82·7	76·0
	79·4	75·8
	85·4	80·2
	88·5	75·4
	91·9	77·9
	93·3	70·5
	94·8	56·1
	100·0	

The operator consulting in the [illegible] the leaching solution has been turned on is completed by the water and gases practically absent at that time. Here a certain amount can be shown [illegible] without losing any of the leaching solution. The operator of the monitor moves with the leaching but is later removed from the system together with the water introduced in the wash so the effluent leaching solution from the [illegible] mine stills.

TABLE III.—*Analyses of Heads and Tails of Leaching Plant.*

	Heads.	Tails.
Cu	1·46	0·58
Cu as carbonate	1·11	0·26
Fe	0·38	0·26
S	0·11	0·17
Insoluble	0·59	0·42
CaO	72·82	72·20
MgO	22·22	22·30

The leaching solution is next circulated downward through the charge, a small centrifugal pump returning the liquor to the top of the vat. Circulation continues till tests show that it has ceased to dissolve copper, or for about 20 hours on the average.

Washing the Charge.—The leaching solution is now drained off, part going to the evaporators, and part reserved as make-up for the next charge. While this rich solution is being drawn off from the bottom of the vat, about 20 tons of weak copper-ammonia solution is pumped on top of the charge as a preliminary wash and follows the rich solution down through the charge. When this weak solution begins to appear at the bottom of the vat, the effluent is turned over from the rich solution storage vat to the weak-solution storage vat.

Immediately following the preliminary wash comes the steam wash. Steam is admitted at the top and gradually heats the charge to the bottom. Pressure in the vat is kept below 5 lb. per sq. in. to avoid distorting the vat and subsequent leakage. The incoming steam condenses in heating the charge, so that a film of condensed water precedes the steam down through the vat, displacing most of the copper-ammonia solution. The remainder of the ammonia, vaporised by the steam, is carried out with it after it reaches the bottom openings in the vat, and is recondensed in a special condenser. The weak ammonia solution is saved in the wash solution storage vats.

When the ammonia content of the vapours issuing from the vat has fallen to 0·5% NH_3, the wash is considered finished, the steam is shut off and the vat excavated with mechanical excavators, as hereinafter described. The time necessary for steam washing, when carried out in connection with the preliminary wash with weak solution, will average 20 hours per charge, and the steam used amounts to only about 100 lb. per ton of material leached.

The steam wash is the greatest single factor in making the Kennecott leaching a success, and upon this portion of the process a patent has been granted. This method of washing enables one to leach rich ores with concentrated ammonia solutions, without incurring an excessive ammonia loss in the tailing, or without using a large volume of wash water, probably several times the volume of the leaching solution, instead of 20% of it as with the steam wash. A water wash is undesirable: first, because water consumption at Kennecott is no small consideration, and also because a large volume will dilute the distilling solution, thereby increasing the cost of distillation proportionately. In fact, the steam economy arising from distillation of solutions which contain upward of 4% copper more than counterbalances the steam used for the wash. In addition, there is the advantage that these rich solutions have little tendency to encrust the walls of the evaporators and stills. This is a point all operators are well able to appreciate.

As water for sluicing is not available at Kennecott and as the shape of the leaching vats permits only about 35% of the charge to run out by gravity a mechanical excavator has been designed and installed in the vats. It consists of a central shaft supporting four radiating arms carrying blades which scrape the tailing to the centre doors as the shaft revolves. It removes the tailing from the vat in about seven hours, using only 1½ h.p. and requiring practically no attention.

In the present plant the tonnage of mill tailing leached has been gradually increased from 3,000 tons in April, 1916, to 10,000 tons in April, 1917. The ammonia loss, at first excessive, has decreased from 2·6 lb. to 0·5 lb. per ton leached. The extraction has varied somewhat but has averaged better than 75% of the carbonate copper. The grade of precipitates has varied markedly but has averaged practically 70% Cu.

In view of the results obtained, construction work has already commenced on the enlargement of the plant to one of a capacity of 25,000 tons per month. The four new leaching vats are to be 30 ft. in diameter, the same as the present vats, but are to be 5 ft. higher, thereby increasing the leaching column from 15 to 20 ft. and the capacity from 500 to 665 tons per charge. The four evaporators, which are periodic in type, are to be arranged in two double effect units, each unit being equipped with a separate condenser and absorber. Arranging the evaporators in double effect will economise the steam used, as a higher grade ammonia concentrate can be produced. By the new arrangement the ammonia concentrate will assay at least 18% NH_3. This will effect a saving of 22% in the steam used for distillation. Should the heads for any extended period assay considerably above the present feed, the amount of solution to be distilled would exceed the capacity of the evaporators, so a third unit has been provided for.

Based upon the figures of the present 300 ton plant, the cost of treating 800 tons per day by ammonia leaching, assuming a heads assay of 1% carbonate copper and a recovery in the precipitates shipped of 75% of the carbonate copper in the heads, is given below. Of the costs, other than the freight and treatment charges on the precipitates shipped, which need not be considered here, the figures for steam, ammonia, and labour are, in the order given, the most important.

The cost of the steam for the operation of an ammonia leaching process will vary with the grade of material treated, since the steam required for the distillation of the copper-ammonia liquors is practically constant per pound of copper precipitated. On the other hand, the steam necessary for the tailing washed is a factor of the tonnage treated, averaging, say, 100 lb. per ton. Assuming a heads assay of 1% carbonate copper and a recovery in the precipitates of 75%, there would be produced 15 lb.

of copper per ton of material treated. With the steam necessary for the distillation amounting to 18 lb. per lb. of copper precipitated, there would be required 270 lb. per ton leached, and with the 100 lb. for the tailing wash, the total steam consumption would be 370 lb. per ton leached. With a net evaporation of 11 lb. of water per lb. of fuel oil, and with oil at $3.25 per bbl. (42 gal.), the cost of steam per ton leached would be 33.6 cents.

TABLE V.—*Labour Costs of Ammonia Leaching.*

	No. of Shifts per 24 Hours.	Rate per Shift Exclusive of Bonus.	Amount per 24 Hours.
Foreman and chemist	1	$6.00	$6.00
Shift bosses	3	4.50	13.50
Operators, distillation	3	4.00	12.00
Operators, charging vats	3	3.75	11.25
Operators, tailing disposal	3	3.75	11.25
Operators, sacking and loading precipitates	3	3.75	11.25
Maintenance	2	4.50	9.00
Firemen (for boilers)	3	4.00	12.00
Roustabouts	3	3.75	11.25
Totals	24		$97.50

On an output basis of 700 tons per 24 hours the cost per ton would be 13.9 cents.

Miscellaneous.—

	Per ton leached
Electrical power, compressed air, lights, etc.	4 cents
Maintenance supplies and equipment	9 cents
Sacking precipitates—expenses other than labour	1½ cents
Sampling, assaying, experimental, etc.	4 cents
Miscellaneous	5 cents

Summary.—

	Cost per ton Leached.	Cost per lb. Cu Recovered
Steam	33.6c.	2.24c.
Ammonia	17.0	1.13
Labour	13.9	0.93
Electrical power, etc.	4.0	0.27
Maintenance	9.0	0.60
Assaying, etc.	4.0	0.27
Miscellaneous	5.0	0.33
Totals	86.5c.	5.77c.

The ammonia used at Kennecott is aqua ammonia, or ammonium hydrate, containing 29·2% NH_3 (26° Baumé at 60° F.). This form of ammonia is more convenient to handle and costs less per lb. of NH_3 delivered at Kennecott than deos the anhydrous ammonia. The cost per lb. NH_3, including the return freight on the empty drums, is 34 cents. With an ammonia loss of 0·5 lb. per ton leached, the cost will be 17 cents.

The costs given in the above tabulation are those estimated for the Kennecott plant when enlarged to have a capacity of 800 tons per day, though to make the costs liberal the labour figures are based on a 700-ton capacity."—HORACE M. LAWRENCE.—*Engineering and Mining Journal*, Nov. 3, 1917, p. 781. (H. A. W.)

MINING.

PRESERVATION OF TIMBER IN COAL MINES.—"At the present time the shortage of timber supplies has rendered the prevention of wastage in pit timber a matter of national importance. A large amount of timber in mines, and especially in shallow coal pits, requires to be replaced prematurely because it undergoes decay and consequently collapses. Such decay or disintegration is, at least for the most part, caused by various fungi which permeate and devour the wood, and often clothe its surface with a fluffy or cottony material ("spawn"). This spawn, usually white but sometimes coloured, can rapidly grow over the timber walls or floor, and may even be broken off and transferred elsewhere, and thus reach and infect sound wood.

"These wood-destroying fungi also produce fructifications, which emit countless microscopic germs ("spores"), which, conveyed through the air, may alight on, and attack, pit-wood.

"Two means of preventing loss through the decay of wood are possible: *preventive* and *remedial* measures.

"Thorough *preventive* measures are largely impracticable at present owing to difficulties as regards machinery, materials and skilled labour. On the other hand, *remedial* measures may be undertaken at once; and it is the main object of this Memorandum to point out what they are, and how they should be employed.

"A. *Remedial measures* are designed to decrease the amount of infection, so that the life of pit-timber will be *lengthened on the average*, and a corresponding saving be thereby accomplished.

Growth of the spawn over the surface of the timber, walls or floor to sound wood is one means of rapid spread of infection, and is aided by the transference of the spawn by other agencies (wind currents, on men's clothes, packing of the rejected pit wood close to sound wood, etc.). The checking of this superficial growth cannot do more than diminish the rate of decay of the timber, because the wood-attacking fungi grow also inside the timber; but inasmuch as the fungus grows more rapidly outside than inside the wood, the rate of destruction of pit-wood will be decreased by killing spawn on the surface.

Infection will likewise be decreased by the removal and destruction of the germ-producing fructifications that emerge from the wood.

In order to accomplish these ends—

1. Colliery timber men should be taught to recognise the spawn and fructifications.

2. *Starting from the intake*, and travelling with the air currents to the return ways, the timber should be periodically inspected for fungus-material on the timber. Where fungus occurs, the accessible pit-wood should be treated as follows:—

(*a*) The apparatus required would be a pail, some cloths, a cloth or cotton swab, a strong knife and an antiseptic solution properly made up.

(*b*) The following antiseptic substances are suitable and are arranged in order of preference:—

(*i*) Creosote, and various derivatives.
(*ii*) Zinc chloride.
(*iii*) Copper sulphate (which should not be used where the mine-water is rich in iron).

(*c*) Every fructification (shaped like a cushion, bracket or mushroom) should be removed by cutting away the portion of wood to which it is attached. These should be placed in the pail, carried to the surface, and burnt in the boiler fires. All waste timber lying in the roadways and recesses should also be brought to the surface and burnt at once. Instant burning is important, as a good deal of infection of sound timber takes place during storage above ground because decaying wood is allowed to lie about amongst it, and so the infection is spread

to timber originally sound. The result of this would be to stop much of the infection that is caused by microscopic germs (spores).

(d) At the same time or subsequently, the spawn on the surface of the pit timber would be dealt with as follows: Each man engaged would carry a swab, the cloths and a pail three-quarters full of the antiseptic solution chosen. All the accessible wood, including props, balks, crowntrees, bars and collars, would be washed with the solution, and the spawn removed. The solution and cloths would require to be renewed from time to time. When possible, loose bark should be removed and the bare wood washed over with the solution.

This treatment would serve both to check the growth of spawn over the surface and to prevent its transference from one part of the mine to another, and thus would hinder new infections. But a certain amount of the antiseptic solution would be absorbed by the wood and on drying would leave on or near the surface a thin film of antiseptic substance which would check the growth of any germs that might alight on the wood.

A great deal will depend on the thoroughness with which these operations are carried out. When once begun the treatment should be systematically and regularly pursued, as these wood-attacking fungi grow rapidly and temporary neglect may undo the work of months. The mine-timber should therefore be examined at least once a month. The consequence of the treatment will be a steady improvement in the condition of the mine-timber from the very commencement. It will, however, be evident that one limitation of the beneficial effects will be due to the inaccessibility of decaying wood packed under the roof above the bulks, crowntrees, bars or collars.

B. The methods detail above constitute a *directed attack on the wood-destroying fungi*, and are designed to reduce the loss occasioned by decay in mines that are already infected. An entirely different method of dealing with the problem is a defensive one, and involves the *protection of the wood* by rendering it immune to infection by fungi.

Wood can be protected more or less perfectly from decay-inducing fungi by coating or impregnating it with an antiseptic substance. The degree of protection thus afforded depends upon the substance used and upon the depth to which it penetrates the wood. Mere superficial coatings are less efficient than injections to some depth within the surface; while perfect protection is ensured solely by impregnating the wood throughout.

Various substances are very unequal in their power of conferring upon wood resistance to fungal attack. In some coal-pits mere soaking with mine-water lengthens the life of the wood; at the opposite extreme of efficiency is creosote, which confers indefinitely long durability upon wood. The exact treatment to be adopted will depend therefore on the circumstances of the case and particularly upon the time during which the wood is required to remain sufficiently sound to be of service. Superficial washes are applied by means of a brush; and when this or any other method of application of the antiseptic is adopted, bark must be removed from the timber before treatment. Somewhat deeper penetration is ensured by soaking the wood for a longer or shorter time in the heated antiseptic solution. For this purpose, timbers, before being taken down into the pit, should be soaked for at least 15 minutes in a vat of 10% zinc chloride at a temperature of 130° F., or in creosote as hot as it can conveniently be used. When the props are put in position in the ways, their tops where bruised by the hammer should be painted over with the preservative, as infection often starts at these spots. For deeper penetration, more prolonged soaking is essential, and the deepest penetration is ultimately secured with greatest economy by pneumatic pressure (and the use of a creosoting plant) if large quantities of wood require treatment.

Creosote and its derivatives, or zinc chloride represent the most economic and efficient antiseptics for use in mines. But a number of salts confer feebler resistance, and may be used where the wood has to last only a relatively short time before being removed: among these are common salt, magnesium sulphate, certain mine-waters, copper sulphate (not to be used where the mine-water is rich in iron): *iron sulphate*, sometimes recommended, *should not be used*.

This policy of replacing timber in mines by wood rendered more or less antiseptic should be followed in all cases. When carried out in the most thorough manner, it gradually brings the pit into a completely sanitary condition (for instance, thoroughly creosoted pit props that when unprotected collapse from decay in a few weeks will last for many years; discarded creosoted railway sleepers similarly will serve for indefinite periods as sound cross bars).

The precise method of dealing with mines in order to eradicate or decrease decay of timber will vary somewhat in detail in different cases. In regard to this, advice may be obtained from the Department of Scientific and Industrial Research.

Note.—The significance of wood-attacking fungi (and possibly certain bacteria) is not confined to their destruction of timber, for during their growth they may produce 'black damp,' and the amount of this gas that they produce is directly proportional to their abundance and rigour."—Department of Scientific and Technical Research.—*Indian Engineering*, April 20, 1918, p. 224. (J. A. W.)

Changes of Address.

Angus, T., *l/o* Kaapsche Hoop; Wankie, Rhodesia

Coaton, A. A., *l/o* Benoni; Springs Mines, Ltd., P.O. Box 54, Springs.

Cullen, W., *l/o* Upper Norwood, London; Cumbernauld, Feltham Hill, Middlesex.

Galbreath, N. M., *to* 1, St. Frusquin Street, Malvern.

James, J. H. D., *l/o* Germiston: Consolidated Langlaagte Mines, Ltd., P.O. Box 15, Langlaagte.

Lloyd, J. J., *l/o* Nairobi; Poste Restante, Diego-Suarez, Madagascar.

Mills, E. W., *l/o* Peking; 75, Yamashita-cho, Yokohama, Japan.

Nakamoto, H., *l/o* Sado, Japan; Mitsubishi Mining Co., Marn-no-chi, Tokyo, Japan.

Olsson, C. H., *l/o* Jeppes; P.O. Box 1126, Johannesburg.

Saner, C. B., *l/o* Isipingo; P.O. Addo, C.P.

Williamson, R., *l/o* Bullfinch: Block 10, Misima Gold Mines, *via* Paqua, Australia.

Wormald, R., *to* Noord Kaap Syndicate, P.O. Noord Kaap, District Barberton.

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THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA

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Vol. XIX. SEPTEMBER 1918. No. 3.

Proceedings

AT

Ordinary General Meeting, September 21, 1918.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 21st September, 1918, Mr. H. S. Meyer (President) in the chair. There were also present:

25 *Members*: Messrs. A. Whitby, H. A. White, H. R. Adam, J. Chilton, C. J. Gray, J. R. Thurlow, C. Toombs, F. Wartenweiler, F. W. Watson, J. Watson, W. R. Dowling, Profs. G. H. Stanley and J. A. Wilkinson, S. Beaton, W. Beaver, N. M. Galbreath, H. C. Hilton, I. Hedges, A. King, P.M. Newhall, S. Newton, E. A. Osterloh, J. T. Triggs, T. P. Waites, and R. H. Wonnacott.

4 *Associates*: Messrs. B. C. Forrest, O. A. Gerber, L. D. Hingle, and J. A. Woodburn.

8 *Visitors*, including Dr. W. Watkins-Pitchford, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the 22nd Annual General Meeting, held on the 22nd June, 1918, as recorded in the June *Journal*, were confirmed.

NEW MEMBERS.

The President announced that the following gentlemen had been unanimously elected members of the Society:—

HARRIS, THOMAS HENRY, Robinson G.M. Co., Ltd., P.O. Box 1024, Johannesburg. Underground Manager.

MORGAN, PERCY YATES, M.A.(N.Z.), F.G.S., 39, Marjoribanks Street, Wellington, New Zealand. Director, N.Z. Geological Survey.

WILLCOX, JULIUS S., 40, North Street, Vogelfontein, East Rand Proprietary Mines' Cementation Works.

The Secretary notified that since the last meeting the following gentlemen had been admitted by the Council as Associates:—

BUST, ERIC GEORGE, Germiston Hotel, Germiston. Battery Shift Leader.

CROXFORD, LOUIS JAMES, Witwatersrand G.M. Co., Ltd., P.O. Box 1, Knights. Battery Foreman.

LANGE, SELIG ABRAHAM, Assoc.S.A.S.M. & T., 79, Height Street, Doornfontein. Metallurgist.

STAPLETON, FREDERICK, Champion Reef P.O., Kolar Gold Fields, Southern India. Reduction Officer.

VILLIERS, JOHN DE, Gold Fields Laboratory, P.O. Box 104, Germiston. Assayer.

OBITUARY.

The President: It is with the greatest regret that I have to announce that since the last meeting the Society has suffered great loss by the deaths of no less than six members: Mr. J. S. Curtis, a foundation member, Mr. G. A. Lawson, Mr. G. F. Matthews, Mr. W. W. Laurie, Mr. John Fleming; and Mr. J. Ferguson, the news of whose death only reached us to-day. It is very seldom that one has to deal with a long list like this, and I do not propose to attempt to describe the loss which each member represents to this Society. Some were known to me personally, others not. Therefore it would be invidious for me to try to call attention to the particular loss the Society has sustained in each of these gentlemen, but at the same time I ask you all to rise as an expression of the Society's condolence with the families of these gentlemen.

This was done.

CHANGES IN COUNCIL.

The President: Although the new year, as far as the Society is concerned, has barely commenced, we have already had two changes on the Council. First, Mr. John Watson has been compelled to resign as he is leaving the country. It is hardly necessary for me to say Mr. Watson has been one of the oldest and most valued members of the Council and to express the regret of the Society at his loss. The last paper Mr. Watson gave us was on the subject of Lithia—and now I understand he is going to deal with the subject of soda, so that it is merely

a change from the mineral water to another! Mr. E. C. J. Meyer, General Manager of the East Rand Proprietary Mines, has found it necessary to resign owing to pressure of business and inability to attend the Council meetings. In their places the following two gentlemen have been asked to fill the vacant seats, viz., Mr. F. G. Macdonald and Mr. G. A. Waterneyer.

AMBULANCE COMPETITIONS.

The Secretary: The Ambulance competitions for the two shields presented by the Society for surface workers and underground workers respectively were held at the Robinson and City Deep mines, eight teams competing for the surface workers' shield and eighteen for the underground workers' shield. The surface workers' shield was again won by the Village Deep, and the Crown Mines regained the underground workers' shield.

District Ambulance competitions have been arranged by the South African Red Cross Society for the mines in the following mining districts on the following approximate dates: Boksburg, November 24th; Johannesburg, December 15th; Germiston, January 19th; Krugersdorp, February 2nd.

Prof. J. A. Wilkinson *(Past-President)*: I should like to say in regard to these competitions that we regret very much that the shield for the coal miners has not been up for competition for several years owing to lack of entries. When this comes to pass year after year, we are almost forced to the conclusion, that, unless a terrible accident happens on one of the coal mines, there will always be this lack of enthusiasm. We have tried every means to create the necessary enthusiasm, but so far we have hitherto failed to do so. The competition this year was a source of great gratification to us because of the large number of teams which entered, and was also interesting from another point of view, as the Kimberley Mines sent up teams for both competitions. In the near future district competitions on the Rand for areas corresponding to the Mining Inspectors' Districts will be held, which we hope will stimulate ambulance work still further. It is very interesting and extremely stimulating to see these teams at work underground, and if any of you can attend these competitions you will always be welcomed and probably very surprised at the excellence of the work done.

The President: It appears to me that the complaint as regards coal mines is pretty well founded, but so long as coal mining is so relatively simple as it is here in the Transvaal it is not so difficult to see why there is not greater interest taken. It occurs to me that if there is not greater interest taken it will be advisable to withdraw this competition and devote the prize to something else. We might devise some other scheme in its place, and I just throw this out as a suggestion, that in view of the fact that to-day natives are being trained all over the mines in ambulance work, perhaps in a small way, why should not this Society, which has taken such a leading part so far in this movement, go one step further and offer a prize for native proficiency in ambulance work?

Mr. I. Hodges *(Member)*: I happen to be the General Manager of one of the largest collieries, and I cannot let this observation pass without a word in reply. I think the great difficulty is that the coal mines are so scattered, that it is very difficult to get coal-miners together in order to provide that emulation which is at the root of these competitions. In our ambulance competitions in England we colliers do not hold ourselves second-best to any class of worker, and although I have not seen the Rand Ambulance competitions, I should not have any fear in putting colliers against any other workers. At Vereeniging we have forty members in our ambulance class—and there is any amount of enthusiasm; but if you ask me if I am going to bring these men to the Rand to compete I should say certainly not. I think there is no lack of enthusiasm on the part of coal-miners; it is merely a question of accessibility.

Prof. J. A. Wilkinson: If it is possible for De Beers to send a team from Kimberley why should not it be possible for the Vereeniging Coal Mines also to send a team to Johannesburg?

Mr. I. Hodges: Because of the relative time in which the men are engaged working. The collieries, owing to the great stimulus the coal trade has received, are working at nearly full pressure—Vereeniging has stood only 2½ days since January 1st. In normal times collieries would be able to find time for the workmen to have ambulance competitions on their mines, but not to travel long distances.

Prof. J. A. Wilkinson: There are only five men in a team.

Mr. I. Hodges: But five out of a colliery staff is different to five out of a gold mining staff, and very different from five out of De Beers' staff.

ASSAY SUPPLIES AND THE UTILISATION OF SOUTH AFRICAN MATERIALS IN ASSAY OFFICES.

Mr. A. Whitby (*Vice-President*): With special reference to local supply of litharge, I wish to make a few remarks. This litharge has been manufactured by Mr. J. F. Ferguson, and every lot has been assayed by our firm. It ordinarily runs about 9 gr. to 10 gr. of silver per ton and negligible gold. Perhaps because it is a local product it appears that the assayers along the Reef have been somewhat suspicious of it. I will give you a case in point. One man found gold to the extent of 0·016 dwt. per ton working on 2 A.T.! Another found 4 dwt. but finally traced it to his fluxes. Now, setting aside the last case, how can any assayer affirm such a result as 0·016 dwt. on a 2 A.T. charge? We certify every consignment of this litharge on samples taken from the bulk before turning, and our method of procedure is to take 20 A.T. in duplicate and run with argol sufficient to give a 30 gm. to 40 gm. button of lead. Finally a wash of argol is given to the molten charge. The two beads of silver are inquarted together with a small piece of pure gold which has been used over and over again, showing no increase of weight. The reason for this is that, supposing gold did exist in the litharge it is probable that on parting the silver bead a difficulty would present itself in collecting any fine gold particles which might be present.

It must be borne in mind that we are dealing with an ultimate charge of 40 A.T., and were there any appreciable quantity of gold we should surely note it. Finally, please, we make no assertion as to the absence of gold in any sample, confining ourselves to the absolute truth that the gold if any is negligible.

Mr. Ferguson has spent a good deal of money in putting in a Pattinson plant, and it is up to the mining community to give him a fair run for his money, and not quibble because it is a local product.

Mr. John Watson (*Member*): I should like to say, in support of Mr. Whitby, that we have been using Ferguson's litharge at the City and Suburban for nine months or a year, and I have made tests of it, doing checks in duplicate on every lot. In one or two cases we found a trace of gold, but on repeating it, the gold was nil. This bears out what Mr. Whitby says. The litharge I have found to be quite all right in other respects.

The President: As a matter of interest, has anyone any idea how this litharge is made? What is the source of the lead?

Mr. A. Whitby: Accumulator plates, at one time.

The President: But now, is it legally mined lead ore or galena?

Mr. A. Whitby: Galena.

The President: Does it come from the Western Transvaal?

Mr. A. Whitby: I do not think so. It is too high in silver there. There is a mine up north somewhere where the silver is very low. He has put in a very up-to-date plant and, given suitable supplies of ore, can produce high grade litharge in sufficient quantity for all purposes.

Mr. H. A. White (*Vice-President*): It is a pity Mr. Ferguson does not come down to tell us something about it; and then we might ask whether he could supply us with sufficient lead-foil for the small quantity we use on the mines.

Mr. A. Whitby: Mr. Ferguson has the matter of assay lead-foil under consideration.

The President: Did anyone see something in the papers recently about the production of lead-foil at Cape Town?

Mr. H. A. White: Sheet lead. That is not quite thin enough for us.

PRODUCTION OF PIG-IRON AT PRETORIA.

Prof. G. H. Stanley (*Past-President*): I expect you have all seen in the press notices that pig-iron is being produced in Pretoria, and I have here some samples for your inspection. You probably know that the ore which is being smelted there is a mixture of siliceous ore from the Timeball Hill range, and a narrow band of clay ore which occurs at the foot of the range, each containing about 50% of iron. The mixture is to some extent self-fluxing, but it is not completely so, and therefore limestone has to be used and brought a considerable distance, and coke is obtained from Natal. At first the plant had its troubles, as is usually the case, and white iron was made; but in a few weeks this was corrected, and the plant is now producing a proper useable grey iron.

It is a small plant according to overseas standards, but it is the beginning of what will undoubtedly be a very important factor in the economic life of the country.

Mr. I. Hodges *(Member)*: Can you tell us anything about Natal coke, what percentage of ash and sulphur there is in it and how far it compares with the best beehive oven coke? I know it is nothing like so long, but it looks hard and dense, and seems to be of a fairly good quality.

Prof. G. H. Stanley: A great many samples of coke have been examined, running all the way from 0·7 to 1·5 in sulphur and 11 to 16 in ash; and even from one district coke is very variable in quality. But it is possible by careful mining selection and more especially by careful washing to produce coke to compare with ordinary coke in use in England; and although I have not seen anything to compare with the best Durham, for instance, a useful coke is being produced.

Mr. I. Hodges: 11 to 16 in ash is very high. It belies its appearance, evidently, because it does not look as though it would have this. You also say sulphur from 0·7 to 1·5. Perhaps by careful washing one might get a coke comparable to some of the ordinary cokes at home.

The President: Why did you get the limestone from Taungs?

Prof. G. H. Stanley: It is the biggest deposit in the country. Where it does occur elsewhere it is in comparatively small amounts, at least, where it is accessible to the railway. It is better to get it from where there is a big supply of a grade which can be relied upon than to have it come from all over the country.

Prof. J. A. Wilkinson *(Past-President)*: I do not think there will be any difficulty in a short time in getting the coke which is required in this country for the production of iron. I have seen the results of tests of shipments which have been to Durham for report; and with careful washing the ash can be brought down to below 10% and the sulphur to below the 1%, which metallurgists require for the production of pig. There is a large steel works in New South Wales where they are using successfully a coke which contains a larger amount of ash than our local cokes. But from what Prof. Stanley has told us, I think the analyses of Natal coke must be checked, as his experience does not bear out the analyses which the collieries give. With careful washing, however, they should bring down the ash content and get rid of a large percentage of the sulphur.

Prof. G. H. Stanley: There were tests made at home years ago with Transvaal coal which were very encouraging, so that it seems that in future we may not have to depend on Natal for our coke.

Mr. H. A. White *(Vice-President)*: We must all congratulate the producers of these pigs, and they ought to be given as much encouragement as possible in sending pigs of this sort to market.

Mr. I. Hodges: I was not aware that, except for about 10 in. of Coronation, there was any coal which would coke in the Transvaal or the Free State. It seemed to me that Transvaal and Orange Free State coals were quite impossible to coke.

Prof. G. H. Stanley: Ash is not so important as sulphur, and there are portions of seams in the Middelburg district which should yield a very fair coke. Those samples of 10 tons each sent home for trial were reported on quite encouragingly. The product was a very good second-rate coke.

The Secretary: In this connection I may state that Mr. Kenneth Austin has been kind enough to send out from England a copy of "A Report on the Sources and Production of Iron and Other Metalliferous Ores Used in the Iron and Steel Industry," which has been placed in the Seymour Memorial Library for the information of those interested.

MADAGASCAR GRAPHITE PRODUCTION.

Mr. T. P. Waites *(Member)*: I want to say a few words, if you will allow me, on that old subject—Madagascar. I have recently returned from it, and, on receiving the *Journals* of this Society which had accumulated, I found an extract in reference to the graphite production of Madagascar.* I find that graphite export from Madagascar was 27,000 French tons in 1917, or 33,000 Colonial tons. Ten years ago it was 8½ tons, so that the industry has made progress, especially in the last 10 years, as none other has of which I have any knowledge. It has been employing several thousand white men and about 200,000 native men and women. It is not underground work. It is all open work. This had become, until a few months

* See this *Journal*, July 1918, p. 7.

ago, the great industry of the country. Now comes the tragedy of it. On account of the lack of shipping facilities the mining of graphite is practically stopped. The buying and export of it was in the hands of chiefly, "Graphites Maskar" (the Morgan Crucible Company), and *force majeure*, in the shape of lack of shipping, compelled them to say, "Although we have made contracts with all of you, to buy your graphite, we are compelled to say we will take 1 ton where we used to take 6 tons; while from July, 1919, we shall take no more. Mauritius has 33,000 tons of last year's sugar crop still on its hands. A record crop this year is expected to be about a quarter of a million tons, and the Imperial Government has said it cannot undertake to export a single ton. Here we are not feeling the war, in the broad sense, but it is circumstances like these I have brought to your notice which make me think we are the "most favoured nation" in this big world-crisis. It has been the custom to throw stones at various institutions—the Chamber of Mines is one of them—but, to come back here and find the lowest grade mine working as if there were no war on, and all the people enjoying the comfort, the food, and the high wages for which this country is noted, I regret that we, as a Society, and, as a "public," do not realise the tremendous amount of organisation the Chamber of Mines, through the Government, has brought about, which has led to such a happy state of affairs in this country, as compared with what I have found in other lands.

THE PRESIDENTIAL ADDRESS.

By H. S. Meyer, Assoc.R.S.M., M.I.M.M.

I propose to place before your notice, in a condensed form, a few notes relative to recent progress in mining and metallurgy in South Africa, with some suggestions in regard to the direction in which members of this Society can advantageously direct their efforts in furthering the interest of this industry, which we all have at heart.

Most of you have been intimately connected for many years with the professional side of the industries from which the Society takes its name; you are fully aware that we are credited by our fellow professional friends in other countries, with great conservatism and lack of originality. Nevertheless, every year something takes place which lifts our technical practice on to a sounder footing, and I make bold to say, very frequently becomes standard practice in other parts of the world.

The past year has been remarkable in the respect that the Union of South Africa has become directly interested in a number of large mining ventures on the Far East Rand, and many who have been accustomed in the past to look upon their employers as residents of Europe, now find themselves—in a sense—"civil servants" of the Union Government, and as employees of the public, who to-day are far more directly interested in mining—partly by purchase and partly through the State interest—than they have probably ever been at any time in the history of this country. A closer, more critical and more sympathetic interest in our premier industry can therefore be anticipated.

In spite of the general difficulties with which we are periodically faced, accentuated by the restrictions necessarily placed on imports, there is more activity in the direction of opening new mines than for many years past. New deep shafts are being sunk on Sub-Nigel, on Daggafontein, on Springs Mines, West Springs (2), New State Areas (2), Modderfontein East (2), Brakpan (2), City Deep, Robinson Deep, Crown Mines (2), Durban Roodepoort Deep, and Randfontein (2), whilst still others are projected. As yet there has been no definite decision as to the superiority of one shape of shaft over another, *i.e.*, circular as against rectangular. On the whole the rectangular still predominates, and a most interesting discussion could be raised regarding their respective merits by the partisans of the two types.

The general scheme of development shows little alteration; in mines where the dip of the formation is small, development in the first instance is carried on broad lines and subsequently in a more intensive fashion, partly for the purpose of more accurate valuation of ore reserves, partly to render the developed ore more accessible for subsequent stoping and partly to secure an evenness of grade, which I fear will always be necessary in order to comply with that unpleasant requirement, viz., uniformity of monthly returns. I have from time to time

heard engineers express their opinion as to the cost to the industry entailed by this demand, and have heard it placed as high as 2s. per ton milled. It seems a great pity that at a time like the present, when the cost of gold production is ever on the increase, the industry should be saddled with an unnecessary burden of this description.

I doubt if this subject has ever been sufficiently ventilated, and few realize the effect on mining costs created by the fact that, in order to maintain an average output over short periods, ore has to be taken from an enormous number of working places, and it is only in exceptional cases that any proper scheme of concentration can be carried out under such conditions.

The system of carrying main collecting roads in Main Reef or in the footwall continues to be the rule in mines where the pressure resulting from great depths renders it necessary to adopt this practice in order to maintain communications; the disadvantage of this system lies in the quantity of valueless rock that is obtained from this form of development. When provision is made to either pack such waste underground or to take it direct to the surface, this system is beyond criticism, but where such arrangements are absent, the quality of the ore mined becomes seriously vitiated.

Turning to the subject of detail development, the practice to-day is to make winzes and raises much wider than in the past. The advantages obtained are numerous; ventilation is improved and stopes can be opened up with greater rapidity, and the additional cost is met by the greater quantity of milling ore obtained; in fact, it may be argued that the width carried should, within reasonable limits, be proportional to the value of the ore requiring development.

Underground tramming equipment of heavier pattern continues to be installed, and the general tendency is to deal with greater loads at moderate speed, requiring heavy and well laid tracks. Longitudinal concrete foundations for incline shafts are gradually replacing transverse wooden sills, which were for so many years regarded as the standard support for the permanent way.

The use of animal transport over short and mechanical haulages over long distances is making gradual headway. I am inclined to think that the value of the former method has not yet been sufficiently realized, taking into consideration the saving of native labour and its relative cheapness and efficiency.

Improvements in stoping practice are extremely slow, and there appears to me no evidence of increased efficiency except where natural conditions or improved appliances are responsible. One may, however, express gratification that after many years' search some types of small machines, *i.e.*, one-man machines, have been obtained, which, it is fervently wished, will gradually replace the hammer boy and some of the heavier types of old-fashioned rock-drills. This type of machine, generally known as the Jack Hammer, is capable in trained hands of drilling the same footage in a shift as half-a-dozen hammer boys under similar conditions. Without going into details at this stage, there is no doubt that this type of machine has come to stay, and those engineers who have been responsible for its design, and the men who have achieved its practical application deserve the thanks of the industry.

The removal of ore from the point where it is broken at the stope face to the nearest collecting station still constitutes perhaps the most difficult underground problem. When it is realized that fully one-third of the total underground native labour force on an average mine is engaged in this apparently simple occupation, it will be understood that improvement in this direction is of the utmost importance. Although numerous ingenious devices are frequently introduced, their nett effect is discouraging. One can only presume from this that as long as the native is kept at one constant level, he will retaliate with a standard of work of which he is the sole arbiter.

A word must be said on the subject of ventilation and prevention of dust. These subjects are being given constantly increasing attention, with conspicuous success, and underground conditions, therefore, show steady improvement. Large sums have been spent on ventilating fans and various appliances for circulating fresh and cool air; the subject of the scientific ventilation of mine workings is more difficult than generally realized, and more study and care will have to be exercised in the control of air currents before anything like perfection can be said to have been attained.

Sandfilling of worked-out areas continues on a moderate scale; the use of this process could be extended with advantage, particularly in mines near the centre of town, with the object of improving the value of the surface. As long as such land is so frequently affected by local underground

falls, it can scarcely be considered attractive from a business or residential standpoint. Apart from this, the removal of large sand dumps would free a considerable surface area of some value, and certainly improve general living conditions in their neighbourhood. It may be noted that the cost of sandfilling through boreholes has been reduced to a very small figure.

The subject of hoisting is more in the province of the mechanical and electrical engineer; it may be mentioned, however, that the tendency is to deal with heavier loads at a moderate hoisting speed. At present hoisting through circular shafts is done in trucks and cages; as, however, there is no particular object in handling the ore carefully, it is quite certain that we shall in the near future see skips running on rope guides or rails, instead of the conventional cage, which will be reserved for handling men and materials.

The subject of the expeditious handling of the underground working force is one which present circumstances are forcing us to specially deal with. The mines, particularly on the Far Eastern Rand, cover very large areas, the workings expand very rapidly, and become every day more remote from the main shafts. The reduction in underground working hours to 48 hours a week makes it highly important that every minute spent below the shaft collar should be given over to productive work, and that the energy and time of the worker should not be unduly wasted in travelling long distances in the mine on foot. Up to date, little has been done in the direction of moving people underground by mechanical means, and there are numerous restrictions against this method, *i.e.*, against the appliances which are available to-day.

I have no doubt, however, that rapid improvement in this direction can be looked for, as well as in improving the means of moving about in mines which are not necessarily large in extent but present numerous natural difficulties against reasonably easy and safe travelling conditions.

Pass now from mine to surface, and turn to the preparation of the milling product, where in a number of cases we reach "no man's land."

In my opinion, the metallurgist should take delivery of the ore at the headgear. He is on the whole inclined to take it in the mill bins. Between these two stand the crusher and sorting stations, which as often as not seem to be regarded as an impediment, preventing the direct delivery from headgear to battery. I have yet to see this important department given the attention it merits, and placed directly in charge of a man of understanding. There are still some who insist that the quartzite and slate forming the walls and partings of the gold carrying portion of the reef mined, which is generally known as waste, and is given away to the Municipality and contractors for road making, is capable either of earning a profit or in an indirect way assists in increasing the profit of a mining company. To my mind, one can equally well claim to draw blood from a stone or turn lead into gold; or it may be expressed in another way, viz., "That which has nothing in it is dear at a penny." However extreme you may consider my personal views, there can be no doubt that with a few exceptions, the metallurgist is using his brains and efforts to extract gold from a large quantity of material which originally contained less of value than the residue he finally consigns to the dumps.

On the Witwatersrand, it may be said that as an invariable rule no mine has started production without an adequate ore reserve. The characteristics of this reserve were known in absolute detail, *i.e.*, the width of the gold-bearing banket, the width of the intermediate waste partings as well as the width of external waste which could reasonably in practice be expected to be broken to successfully remove the valuable banket. Fair estimates are also procurable of the probable percentage of valueless material which reaches the surface in a condition for subsequent rejection. Granted this, it is only reasonable to expect that the whole design of the crushing, sorting and milling plant should be based on mining conditions. Were this the case, I could not accuse you of crushing and cyaniding enormous tonnages of valueless road metal, and of stating in good faith that you obtain 96% extraction out of nothing.

Given well designed and properly controlled crushing, screening and sorting plants between headgear and mill, the existing metallurgical equipments erected on this Rand to-day could, I have no hesitation in stating, produce far more gold and profit for a very limited expenditure on improvements in the direction indicated. The position, however, is that most plants have not been designed on this basis, and consequently many mines are found to be overstamped and consequently overmanned. They then

become so inelastic that they are unable without most drastic methods to adapt themselves to the altered conditions brought about by complete changes in underground conditions. There seems little chance of shaking off our heritage, but one may be excused from expressing the hope, that the many new plants we expect to see erected in future will be designed in such a way that they can be adapted to meet the possible changes in geological conditions which cannot be foreseen at the time of their erection. I can see a plant of the future where the stamp battery instead of being the most important means of comminution, is the least. Fines will be by-passed direct to tube mills; double stage crushing and sorting enables the tube mill pebbles to consist entirely of valuable banket, a maximum amount of waste is discarded and the stamp battery has only to deal with the relatively small quantity of indeterminate material. The battery could always be extended to suit any improvement in the proportion of reef to waste. Metallurgical efficiency has now reached a point where there is little scope for improvement in extraction, and any advance must take the form of design rather than practice. Alterations must therefore be somewhat revolutionary, and aim at a reduction in capital cost rather than operating expenses.

My original intention was to review very briefly, some of the technical features of this industry which I hoped would interest you, and I find myself introducing subjects which to say the least, are controversial. For this I must apologise, and at the same time point out that sufficient matter has been touched upon to indicate the lines on which interesting papers could be written, and I ask those of you who are specialists in some of these subjects to come forward with your views, so that the matters can be discussed in the friendly, free, and professional style which this Society has ever encouraged.

Although we are proud of our School of Mines and its influence on technical training, it occurs to me that many whose intion is to qualify as mining engineers are not sufficiently acquainted with the Government Miners' Training School, and to the good results obtained from it.

It will be remembered that the Government decided in 1911 to establish a Government Miners' Training School in order to provide the South African youth with the necessary means, under the most favourable conditions, for obtaining a course of training in what must be recognised as a skilled trade, viz., mining.

The scheme has considerably expanded, and there are schools at the Wolhuter and Bantjes mines and one in course of erection at Modder B.

Young men of good physique and reasonable education and qualifications, between the ages of 16 years and 25 years, are accepted as apprentices for underground work for a period of two years, during which period a progressive wage is paid as follows:

First six months	...	4s. 3d. per day.
Next six months	...	4s. 6d. ,,
Next six months	...	4s. 9d. ,,
Next six months	...	5s. 0d. ,,

Apart from wages there is a scale of bonuses, so that the industrious apprentice is able to add materially to his wage. From the wages earned a certain amount is deducted for board and quarters, medical and benefit society, and recreation fund, and the apprentice is left with £2 or £3 pocket money per month. After completion of his two year's apprenticeship, the apprentice receives preference over all other candidates for employment on the mines, at a wage of not less than 16s. 8d. per shift. I think you will agree with me that such an opportunity, and under such conditions, for learning a skilled trade, is unique in the world of industry.

At the end of August there were 188 apprentices on the books of the schools; many have already completed their training and are now occupying remunerative and responsible positions on the mines.

Now the point of importance to those who contemplate giving their sons the training of a mining engineer is this. Whilst the boy is young and hefty, he has in the Training School a unique opportunity of learning in practice the roughest part of mining, and doing that part of the practical and dirty work which few men have the grit to undertake later in their careers. Instead of young fellows commencing their careers as junior samplers and surveyors, I offer the advice that they should learn the practical side whilst their bodies and mind are adaptable. They always have a trade to fall back upon, and there is no restriction to their future progress.

There is just one more subject of a more general nature that I must mention before concluding:

Our Hon. Vice-President, the President of the Chamber of Mines, has been brilliantly successful in bringing employer and workmen into closer touch, and a basis of mutual understanding has been created equal to that known in any other industry the world over. My observations compels me to the opinion that the give has all been on one side. From the employee's standpoint, the Witwatersrand can well be called 'The Mining Utopia.' Is he, however, giving a fair return for these exceptional conditions? I am in a position to follow efficiency returns from a large number of mines, which, taken as a whole, can safely be regarded as representing average conditions along the Reef; the disconcerting feature revealed by such figures is, that in spite of unlimited expenditure on improved appliances, on lavish living conditions, on better educational and training facilities, and finally on higher wages, there is no evidence of improved efficiency. Is it, therefore, too much to ask the mine worker of whatever grade to show some consideration for the employer, and to endeavour to give a little in return for benefits which cannot be equalled in any other mining camp in the world?

Mr. H. A. White *(Vice-President):* It is unusual, and not quite in accordance with precedent, to discuss the Presidential Address, but it is also permitted to the proposer of the vote of thanks to take the opportunity of saying a few words, and I propose to avail myself of that to-night. The address has been one of rather wider scope than we are accustomed to, and I think the Society is to be congratulated on possessing a President who shows that he has so firm a grasp of such a wide range of subjects of interest to the members of this Society and to the public who depend on the mines. One or two subjects are controversial. For instance, I have been on the Rand sixteen or seventeen years and have not yet met with "waste free from gold," and this question of waste elimination on the surface is a subject—on the part of mining and mechanical engineers—generally handled with more enthusiasm than discretion. Even underground sorting has its pitfalls. There is one mine not so very far from here where four successive managers have said they have removed the "waste packs" of their predecessors, and put them into the mill, where they averaged nearly the same grade as the rest of the ore. Metallurgists have gone into this question, and they know that this waste which carries nothing is only to be found on paper. It cannot be found at the surface amongst the ore mined on the Witwatersrand. The average residue may be put at 0·3 dwt., and the average of waste value is two to three times that; and the difference as a rule with our big mines will pay for extraction when once allowed into the stream of ore. Depreciation of ore in depth has been sufficiently dealt with in the Presidential Address of a sister society, but there is another important point in connection with depreciation, and that is depreciation of the ore in time. In the last two or three years our gold has depreciated very considerably because Governments have put on an unfair competitor in the shape of unlimited issues of paper, so that instead of relying on our gold to produce the basis of credit, and the means of exchange, they have been extending these issues at such a rate that the gold no longer will pay the same real wages or procure the same amount of stores which are still necessary to produce the same amount of gold. Therefore we get many suggestions for relieving the position, some of them very absurd, as in the way of increasing the price of gold—for the price of gold in the bar and in the sovereign must, of course, equal one another. There are, however, reliefs which the Government could give and which would be felt very directly on the Rand. They could reduce some of the excessive taxation where it is most heavily felt and let some of the other producers in this country, who are reaping the benefit of the war, bear a little of the taxation, and so relieve the mines. I beg to propose a hearty vote of thanks to the President for his able address.

Mr. A. Whitby *(Vice-President):* I should like to second the vote of thanks to the President. There is one remark by Mr. White which I must emphasise. He used the word "reaping." Naturally he refers to the farming community!

The vote of thanks was carried by acclamation.

The President: I am extremely gratified at the way in which you have received my few remarks, and particularly at the way in which Mr. White has proposed a vote of thanks. I hope later on to have the opportunity of crossing swords with him on the much-debated subjects brought forward.

THE EFFECTS OF DUST INHALATION

By J. S. Haldane, M.D., F.R.S.
(Hon. Member).

(Printed in Journal, July, 1918.)

DISCUSSION.

The President: The Society is honoured by being in a position to place amongst its proceedings the valuable paper submitted jointly to the Institution of Mining Engineers and this Society by such a distinguished authority as Dr. Haldane.

The paper has been in your hands some time, and the important experimental work, on which the general conclusions are based, has without doubt stimulated the interest of medical and mining men, and we hope that the former will open the discussion. We miners are in their hands, and it is to them that we look for advice as to the remedies and conditions advocated, so that the dread disease from which we are liable to suffer, can be combated. To us, to a large extent, must be left the practical adaptation of the methods advocated, and I can safely say that any remedy in technical practice which is within the scope of the mining engineer, will be heartily welcomed and willingly supported in order to eradicate or at least prevent, the one thing that gives our mines a bad name.

It remains for you, in the course of this discussion, which I trust will be of as much interest as the paper itself, to express your views as the practicability of the proposals which Dr. Haldane hints may be a basis for improved conditions.

The Secretary: A note from Dr. Haldane accompanied the paper, and in this he says "the matters referred to in the paper can probably be better discussed by your Society than anywhere else, on account of the general interest in the effects of dust inhalation and the wide experience of different mining districts of many of the members. The paper also indicates the possibility of a new means of preventing miners' phthisis, and this will, I think, prove of interest."

Mr. J. Chilton *(Member of Council):* I am sure we are very greatly indebted to Dr. Haldane for his paper. Something new can always be said on the question of miners' phthisis, and Dr. Haldane attacks this disease from an entirely new standpoint, and, to myself, as an old coal miner this comes with particular interest. It seems to me if Dr. Haldane's premises are correct, I shall have the pleasure of sending down to Mr. Isaac Hodge's coal mines three times a year, the whole of my underground staff so that they can get the silica out of their lungs. It would be quite a simple matter to stimulate the lungs of the miners by such means as making them go through a coal dust chamber. We could even spray our stopes with some dust mixture of a stimulating character, or else use some form of earth in the tamping. In fact, if Dr. Haldane's premises are correct, in various ways the subsequent steps are quite practicable. I spoke to the Secretary of the Miners' Phthisis Compensation Committee, and he told me it is quite a simple matter to follow the history of men who had left here and gone down to the coal mines in Natal and other parts of the country. I think it would be a very good thing if our Mine Managers' Association or some other body would get into communication with the mine managers on the coal fields and follow up these men to see what is the effect of work on the coal fields on men who have suffered from silicosis. As an old coal miner, I had the idea that the effect of breathing coal dust is certain to simulate the lungs; while on just taking a cursory glance amongst the men who have left the coal mines in England and come to the gold mines in this country there seems to be no doubt that the fact of a man having been in the coal mines is greatly to his benefit when he comes to the gold mines.

I wish to move a vote of thanks to Dr. Haldane for his remarkable paper.

The President: On your behalf I should like to welcome Dr. Watkins-Pitchford (the Director of the Miners' Phthisis Bureau) to this meeting, and to ask if he will be good enough to give his views on this paper.

Dr. W. Watkins-Pitchford, M.D.Lond., F.R.C.S., Eng. *(Visitor):* Dr. J. S. Haldane's communication is not only an able paper, as one would expect, but is also one which may prove very valuable. The main deduction it appears to invite is that, if coal-dust, or shale-dust, be simultaneously inhaled with siliceous dust, the last-named dust is rendered much less noxious or possibly entirely harmless.

A practical application of this proposition, as it stands, to the mines of the Rand would be, of course, contingent upon the overcoming of many difficulties. I do not think that

any attempt should be made, at present, to apply it in its most obvious form, *i.e.*, the intentional enriching of the air of our underground workings with coal-dust. The time for such procedure will come when Dr. Haldane's observations and Mr. Mavrogordato's experiments have been definitely confirmed; and when they have also been shown to be as applicable to man as to experimental animals.

If one of the effects of the presence of coal dust in the tissues of the lungs is indeed to hasten the escape of siliceous particles, it would seem justifiable to assume that its inhalation would have a certain amount of remedial as well as preventive effect; in other words, a man with an unusual number of siliceous particles in his lung tissues, *i.e.*, a silicotic, should be enabled to get rid of them more rapidly if he inhales coal-dust. An experimental test of the soundness of the theory, and of this deduction from it, could be made without much trouble. It might take the form of securing employment for a number of cases of uncomplicated silicosis in the coal mines of Northern Natal, or Middelburg, and obtaining the assistance of the Medical Bureau in comparing the progress of these cases with that of a similar number of cases following other occupations. The notoriously low death-rate from pulmonary tuberculosis amongst coal miners in all countries (to which attention was called by Wainwright and Nicholls in 1905) should be an additional inducement for us to initiate such a test, and should also encourage volunteers for the experiment from among our silicotic miners.

Dr. Haldane's suggestion that the entrance of coal-dust into the lungs may assist them in voiding any tubercle bacilli which might otherwise vegetate there is very ingenious; it appears to me to be the most rational hypothesis as yet brought forward to account for the relative freedom of the coal-miner from pulmonary tuberculosis. If the hypothesis is sound, and if by following the occupation of a collier a silicotic miner could indeed save himself from the dreaded tuberculous complication, humanity in general, and the gold-miner in particular will be under a great debt to the person who was responsible for the suggestion.

Let us, however, beware of an uncritical optimism. It is not true, as many people believe, and as I myself believed until recently, that coal-mining does no material damage to the lungs; if coal-dust inhalation be sufficiently long-continued, the relatively harmless condition of anthracosis may pass gradually into one of definite and gross fibrosis. The structural damage to the lung produced by the inhaling of coal-mine dust appears to differ in no essential from that which is characteristic of uncomplicated silicosis; it is merely a matter of degree. The only vital distinction between the two conditions is that a fibrosis due to silicosis is unusually liable to tuberculous infection, whilst that due to anthracosis is not. Several explanations have been offered for this difference in liability, and Dr. Haldane has now offered another one. Our records at the Medical Bureau, which are now complete for over 28,000 men, include those of many coal-miners who have never worked in quartzitic rock; several of such men afford quite definite evidences of incipient fibrosis of the lungs, and in one case—that of a man who has worked only in the South Wales collieries for 31 years—the signs, both auscultatory and radiographic, are typical of the primary stage of silicosis.

In view of the fact that the inhaling of coal-dust, like that of siliceous dust, can give rise to fibrosis, we have to ask ourselves whether, if we set a silicotic miner to inhale coal-dust, it will do anything more than assist him to get rid of the silica, whilst leaving his fibrosis either unaffected or accentuated. This is, of course, merely speculation, but the discussion on this communication must necessarily be mainly of a theoretical character.

An observation which has been made by Dr. James Moir and myself appears to be of some importance to this aspect of the subject—it is, that there is no constant relation between the amount of new fibrous tissue in the lung and the number of siliceous particles present. In areas of very extensive fibrosis there may be an almost complete absence of quartz particles. This phenomenon is sometimes especially noticeable in the fibrotic nodules and masses found in the lungs of men who have abandoned mining for many years. If siliceous particles were originally present in such fibrous tissue, they have, for the most part, escaped and gone elsewhere before the man's life came to an end. We are tempted to conclude that, even if the excretion of quartz particles were greatly accelerated by the inhaling of coal-dust, the fibrosis might still continue for a long time.

I think that the natural excretion of quartz particles from the gold-miner's lung is probably a little more actively carried on

than Dr. Haldane appears to suggest. The expectoration of a coal-miner is black, or dark-grey, in appearance for many months, or even years, after he has abandoned his occupation; in other words one can *see* that the particles of coal are being excreted. One does not similarly see the particles of quartz in the expectoration of a silicotic, because they are almost colourless, but one should not therefore conclude that they are being retained in the tissues of the lung. It is usual, when polarized light is employed, to find that some of these particles have been excreted into the air-cells and air-tubes of a deceased gold-miner who may have given up his work many months previously.

Dr. Haldane's suggestion that the presence of silicates with crystalline silica in a hard rock renders the silica relatively harmless, when the dust of the hard rock is inhaled, does not appear to me to be quite valid. The mortality from so-called "phthisis" in England and Wales, amongst granite-cutters, at all ages, is in excess of the standard for all occupied males.

With regard to the apparent harmlessness of the quartz in shale, to which Dr. Haldane draws attention, and which he attributes to the silicate which accompanies the quartz—I think that this may possibly depend upon the relatively large size of the quartz particles which are liberated when the shale is broken. Sand-dump dust is relatively innocuous, whilst the dust of dried slime is potent for evil. When a quartzitic rock is fractured by blasting, or abraded by drilling, the siliceous dust which is generated includes, as we all know, a considerable proportion of excessively fine particles: so fine that they will float in the air for several hours. It does not seem probable that the crushing of shale can give rise to such impalpable and dangerous siliceous dust; but this question, like most of the other questions raised by this admirable paper, should be put to the test of experiment.

The President: On behalf of the Society, it gives me great pleasure to express our thanks to Dr. Watkins-Pitchford for his contribution. He has opened the discussion in an extremely able way, and apart from that, it gives those of us who are not so conversant with the subject, a line of thought which will help us to appreciate the whole motive and aim of Dr. Haldane's experiments.

Mr. J. M. Neill *(Member):* To my mind the subject matter of this paper is the foundation on which hopes of eradicating miner's phthisis must be built.

As, however, the actions of what may be called the beneficial dust depend on two principal factors, one physiological the other physical, it would be wise to consider certain local conditions before advising any miner to try the effects of diluting the harmful silica dust, by inhaling an atmosphere already charged with graphite coal or shale dust. Charging the lungs with special protective dust should not present any difficulty as men going to and from work could pass through a dust chamber in a certain time, and could even during shift go into a dust cabinet containing a known dust content, kept in suspension by air jet or fan.

The local conditions, which may be unknown to the author, and upon which so much may depend are, a depth which may be as much as over 5,000 ft. at which many miners do their work, the temperature of the working place, the quantity and quality of the water (fog or mist) breathed as well as the silica dust which contains from 3% to 7% or more of pyrite.

I draw attention to those matters as the author has shown that the epithelial cells are responsive to stimulating influences, and it may be just possible that the sudden increase of pressure due to a miner reaching his working place, 5,000 or more feet below the surface in a few minutes (and *vice versa*) will have the effect of destroying any such stimulating influence. There is also the point regarding the power exercised by some solids, called adsorption, which seems to act on the molecular surfaces in a manner more closely allied to physical than to chemical force. The physical difference in trials made under dry-as-dust conditions, and experiments which may be made here under very different physical conditions of temperature pressure and moisture, may tend to alter the adsorptive quality, especially in the presence of fine pyrite, with disastrous effect.

As this is a matter which concerns the well-being of everyone in this country, I would suggest that this society furnish the author with all available data at its command. He may then be able to prove that such actions as he has already demonstrated will follow a normal course here in spite of local conditions. We will then, I am sure, be able to produce from among our mining members, men who will make personal trials. I have had one official tell me that he is tempted to begin already.

On the other hand it is possible that our mining laws will have to be altered, and all water drills and sprays be done away with (except immediately after blasting for the solution of harmful gases) in favour of definite proportions of beneficial shale dust of a type that would not injure our metallurgical processes. The miner may also have to make his journeys up and down at a reduced speed.

The term quality as applied to water breathed includes both its physical condition and chemical constitution. Depending on the quantity present and the temperature, it exists physically as jet, spray, mist (natural or artificial) and as aqueous vapour. From quite a number of observations at one mine 7° at 75·5° F. was the greatest difference recorded between dry and wet bulb, the general average difference being about 3° at 75·5°. Saturation is commonly reached as the presence of natural mist in the mine indicates. Chemical composition of the water depends upon the supply available and used at each mine for damping down rock and for producing sprays and artificial mist. In some cases this supply is alkaline, in others acid, and naturally the sprays and artificial mists will be of similar character.

Barometer readings at start and finish of trip and net time of making trip in the cage and to the deepest workings, together with dry and wet bulb readings would, if carefully compiled, be of value to the author. Anyone coming forward with facts touching on the above will be helping to solve the problem of miners' lung diseases.

Mr. I. Hodges *(Member):* I read the paper of Dr. Haldane when it was first printed, and I was very much impressed in that the results of experiments made in Great Britain during the last five years should have induced Dr. Haldane to consider how far shale-dust as now applied to coal mines would be a deterrent to phthisis if applied to gold mines. When I got a letter from the Secretary asking me to be here to-night to assist in the discussion I took particular care to be present, because although I have been a member for many years I have not attended the meetings as Saturday night is not suitable for men from the country who have to give up the whole of Saturday and Sunday for one meeting.

As to the reputation of Dr. Haldane, I need say nothing. His researches into the best method of detecting carbonic oxide, often carried out with considerable danger to himself, excited our warmest admiration, and when the awful loss of life resulting from coal mine explosions was forced upon the world by the Courrières explosion in March, 1906, and it became a question whether coal mining could be allowed to continue on such a vast scale, Dr. Haldane again came to the aid of the coal mining industry by assisting in the experiments undertaken by the Mining Association of Great Britain at the request of the Royal Commission on Mines. A great controversy had arisen as to whether coal dust was of itself explosive without the presence of gas; and as to what would prevent coal dust explosions passing throughout the whole mine. I advocated dustless zones,—stretches in which the road-way was arched with brick and which were kept clean of dust. The Mining Association of Great Britain decided to experiment on a large scale and constructed a tube about 900 ft. long and 7½ ft. in diameter. They rigged this up with track, sets of timber and all that pertains to actual underground work, strewed it with coal dust, and proceeded with their experiments. It was quickly proved that coal-dust, without any admixture of gas, was explosive. Dustless zones were found to be of no permanent value, as the "pioneering" wave from an explosion approximating a speed of 1,000 miles per hour easily passed any reasonable length of dust-free zone. From the investigation into the Courrières explosion in the North of France it appears that there were some of the roads which the flame had not traversed; and eventually it was ascertained that when shale-dust reached 40 to 50 of the dust in the road-way, the flames could not continue. It was then suggested that collieries should dust their road-ways with 50 of shale-dust; and the Mining Association experiments proved that coal-dust was thus rendered quite innocuous from the point of view of explosions, which entirely removed the fear that had oppressed all managers of coal mines from the occasional holocausts that had occurred in connection with collieries. Then the question arose as to the effect the silica in the shale must have on the health of the miners. Dr. Haldane investigated the effect of this siliceous dust, and it was found by experiments carried out at the University of Sheffield on guinea-pigs and other animals that it had very little deleterious effect. But beyond this it was discovered that the life of the old colliers

was steadily increasing. On one mine on which I was manager we had a collier 74 years of age, who had worked underground for 67 years. A Scotch colliery-manager cited a collier of 82, who commenced work when he was 10, and during the 72 years he had worked on the mine had never had more than three weeks off! Though our Home colliers do last this length of time I would say their work is certainly more arduous than the work of a miner in a gold mine. I have been in this country for the second time, seven years now, and have had daily experience of the miners' duties here. I find them about consistent with the duties of a deputy at Home, and in no way so arduous as the work of a collier there. Dr. Haldane has said the question of bronchitis, etc., in the later stages of the collier's life, depends somewhat upon the amount of physical strain he has had to put into his work in earlier life. In my opinion the health of a gold miner depends pre-eminently on adequate ventilation. Where there is a large percentage of "black damp"* he breathes double the amount of air which would be required if the air was pure, and in breathing double the amount of air takes into his lungs double the amount of dust. One reassuring feature about gold mines is that ventilation is increasing, and purer air is being provided at the working-faces; but I am quite sure that the ventilation of the gold mines is still not comparable with the ventilation of coal mines in Great Britain. One of the coal mines I had charge of had 500,000 cub. ft. of air per min., and not only passing through the mine but a great deal of it passing through the actual working places. I was very interested in what Watkins-Pitchford said, but I may mention that my uncle started work at seven years of age, and was daily in the coal mine, and he had no sign of bronchial trouble when he died at the age of 65, and this is no infrequent thing. There are 600,000 colliers employed in underground work in Great Britain, so the data are fairly reliable and do not allow much margin for error. The current belief amongst colliers, although I would not like to go so far as to say coal-dust makes a man immune from tuberculosis, is that coal-dust in no way assists tuberculosis; but, on the other hand, appears in some way to help against the inroads of tuberculosis.

Dr. Haldane in his paper to the Institution of Mining Engineers on the Health of Old Colliers, says:—

"To put the matter into metaphorical language, coal-dust and shale-dust, when introduced into the lungs, summon up the activities of thousands of tiny housemaids, who collect and gradually make away with the dust. If the quantity of dust inhaled is not too great, therefore, the cleaning-up process keeps pace with the introduction of the dust, and no harm results."

"Coal-dust certainly does not kill germs; but it has come to be regarded by medical men as a preventive of phthisis. It seems probable, therefore, that the 'housemaid' cells which clear out the dust-particles clear out at the same time other 'foreign bodies,' such as tubercle bacilli. If this is so, coal-dust in moderation is, on the whole, and despite explosions, an advantage to the safety of colliers."

"The question whether one dust is not an antidote for another is now being worked out—whether, for instance, a dust which by itself would be dangerous would be rendered innocuous in the presence of coal-dust. Thus the introduction of coal-dust into the Transvaal mines might result in clearing out from the cells of the lungs the whole of the dangerous silica dust as well as other harmful matter."

Some discussion has arisen as to whether the higher wages and better conditions of the last generation has given miners more bodily strength to resist disease. Wages at Home are so much lower and the standard of living so much lower than here, that if this factor has any vital effect South Africans ought to have immensely the benefit. I may say that experiments in the direction of Dr. Haldane's suggestions would be of very small cost. In a colliery having 80 miles of underground roads, the actual expense of dusting the whole of the road-ways so as to render explosions impossible does not run to more than about £40 to £50 a month. The shale which falls from the roof is taken out of the mine and ground up to run through a mesh of about 100 to 1 inch, and the dust is then distributed by hand, being thrown on the roof and sides of the road-ways—shale-dust clings even to the vertical surfaces. As to its resistance to air currents, experiments have proved that at velocities less than 2,500 ft. per minute shale-dust is not disturbed, above which speed it is carried away by the air-current as a cloud. During the heavy blasting of gold mines it is likely that the shale-dust from shale-dusted roads and working-faces would mix with the fine quartzite dusts in

* Black damp is, as a rule, confined to collieries.—Ed. Com.

the air-currents, and thus create the conditions desired by Dr. Haldane.

In reference to the remarks of my coal mining colleague, I agree that there is but little chance of a man with silicosis going into a coal mine and recovering, or even being ameliorated. I have had several silicotic gold miners down at the colliery at Vereeniging without their receiving material benefit; perhaps they were too far gone before they came to coal mining, but I do not really see how the small angular particles of silica already embedded in the lungs can be removed by any subsequent inhalation of coal dust. But I do think that a collier whose lungs have been trained to get rid of coal-dust would resist your quarzite dust conditions better and put up a stouter fight against phthisis than a man who came straight off the veld with no industrial heritage. Men vary enormously in their capacity to stand the ravages of mining, and I believe that a preliminary period in coal mines would in a large measure give greater resisting power than is possessed by men starting straight away in a gold mine.

It does not seem to me that the Rand has ever made in connection with the miners' phthisis problem anything like the decisive experiments which the Mining Association of Great Britain made in connection with coal-dust explosions. That Association went to the expense of a very large sum of money and put its best brains into the work, and in twelve months' time had found a remedy. If a committee were formed to investigate Dr. Haldane's suggestion, funds would not be a serious obstacle; I cannot see that it could possibly do any harm, and I am convinced it has elements in it of good; and when a scientist of Dr. Haldane's reputation makes suggestions, after all the years he has spent in the investigation of coal mining problems, they deserve the fullest consideration on the part of this Society, not only in debate but in actual experiment

THE ESTIMATION OF INJURIOUS DUST IN MINE AIR BY THE KOTZÉ KONIMETER.

By John Innes (Associate).

(Printed in Journal, March, 1918.)

DISCUSSION.

Mr. J. Hayward Johnson *(Member):* During the discussion on Mr. Innes's most useful paper, it has been stated several times, that the status of the dust sampler should be raised. To attain this, I think all dust and air samplers should be appointed by the Government Mining Engineer and be directly responsible to him. This would obviate the possibility of "sampling to order." They should be paid a uniform rate of wage in accordance with the responsibility of their position. Samplers are but human, and the line of least resistance is as likely to be followed in their case as in others.

Why should not dust and air samplers held certificates of competency? An assayer who does the analyses has to hold a certificate. Of what use are the most perfected instruments or the most carefully performed analysis, if the samples are taken in such places as would show misleading results? A dust or air sampler should rank, at least, on the same level as a shift boss, and be independent of *all mine officials*, to be able to carry out Regulation 161, par. 10, of the Mines, Works and Machinery Regulations as amended 1917.

NOTES ON THE REMOVAL OF A VERTICAL SHAFT PILLAR.

By J. Chilton (Member of Council).

(Printed in Journal, June, 1917.)

DISCUSSION.

Mr. J. Allan Woodburn *(Associate):* This paper is most most interesting and should bring forth some discussion on the question of size of pillars necessary for complete protection; also, as to whether in many cases, especially in deep mines shaft pillars should not be dispensed with entirely, as well as all other pillars of solid reef.

In flat workings where the seam or reef is lying practically level, the shaft pillar will naturally be of equal size on all sides, unless some fault is known to exist nearby which might necessitate a modification of the shape, but in inclined reefs the area of a suitable protecting pillar must be modified according to the dip of the formation. To take an extreme case, if a reef were dipping at, say, 75 degrees, and a vertical shaft were sunk, say, 300 ft. on the dip side of the outcrop, so as to cut the reef at 1,000 or 1,100 in depth, then the shaft pillar necessary for protection would be much wider at the level of the shaft bottom and gradually taper right up to surface in longi-

tudinal section, while in cross-section the extent of the pillar on the rise side of the vertical shaft would be practically equal to if not greater than the depth of the shaft; whereas on the dip side it need not be much more than 100 ft. in length.

Where a reef is dipping at, say, 30 degrees, then the pillar should be at least twice as large on the rise side as on the dip side for equal protection, because in stratified formation the strata tends to break at right angles to the dip, whilst on the level sides of the shaft it will naturally be the same on both sides.

The fact that a large amount of development work is usually carried out prior to stoping being begun on a gold mine, naturally establishes a shaft pillar of ample size in the first instance, and the question of ultimate area of this pillar is not determined until after stoping begins and sometimes not even then, but until stoping has been carried on for some time. Now, if stoping be carried on so as to unduly reduce the area of solid reef especially on the rise side of a vertical shaft, there is more danger to the shaft by leaving the balance of the solid ore unworked than by taking the whole of the reef out as rapidly as possible. If enough solid reef is left in to protect the shaft all is well, and this ore can be taken out near the end of the life of the mine, though the cost of stoping it then will be greater than it would have been at the beginning owing to the broken nature of the hanging-wall all round. As it is difficult to decide on the actual size for a really protective pillar at 3,000 ft. to 4,000 ft. in depth with reef dipping at 25 to 30 degrees, in order to be on the safe side the pillar may be of such a size that development to the boundaries and stoping back to the shaft may probably not mean much extra expense in development and delay. The danger of leaving too small a pillar and thus causing serious trouble during the earlier life of the mine forces one to seriously consider the advisability of taking out the ore all round the shaft as soon as stoping begins, that is to say, starting stoping about 1,000 ft. away from the shaft and at the same time starting also at the shaft and carrying on this work simultaneously so that in as short a time as possible the area of what would have been the shaft pillar together with an additional area all round will have been stoped. This would cause an even subsidence all round, and if properly packed would allow of settlement of the hanging-wall in a regular manner without serious breaks in any direction.

In the case of the South Reef pillar in the Village Main Reef shaft, the 60,000 sq. ft. was altogether too small and was really the cause of the collapse of the lower 200 ft. of the shaft, much in the same way as the 12 in. diameter air pipe collapsed as the result of pressure in the sand filled area. In the case of the shaft the strata all round were tending to settle down and pressure was considerable all round, and if there had been no pillar the strata would have settled gradually on the packs or sand-filling, and practically no damage would have been done but the pillar tended to prevent the strata subsiding, and the pressure caused the shaft to collapse just like the air pipe.

The more one studies the mining problems on the Rand, the more one is impressed with the necessity of applying coal-mining experience, and it would be of great benefit to the mining community generally if careful data were collected in stoping at considerable depths of the amount of subsidence in each stope and the distance from the face where the greatest amount of settlement takes place. That is to say, in stoping a reef about 5 ft. thick and building pigstyes or pack-walls, the hanging-wall will come down until the height between hanging- and foot-wall will only be about 2 ft. 6 in., and it will remain at this reduced width for some considerable distance, but the distance from the face to where the space between foot- and hanging-wall is reduced to 2 ft. 6 in. will be a variable one according to the angle the face bears to the line of dip and the total length of the face being worked in that direction.

In coal mining, as the aim is to get as large a tonnage of round coal as possible per shift, and as excessive pressure on the face tends to make the coal harder to mine and also produces more small coal, the question of pressure and how it can be controlled so as to relieve the face is of paramount importance, and only by taking careful notice of the line of break of the hanging-wall and altering the line of the face, or increasing or reducing the pack walls is this regulated, and the ability to thus regulate the system of working makes up a very large proportion of the value of the experienced coal miner.

In Mr. Marriott's recent Presidential Address to the Institution of Mining and Metallurgy, London, speaking of some of the improvements and changes which had been made in Rand mining, he says:

> "The change was affected through "the appreciation of the fact that the "two great branches of mining, coal "and metal, were not so far apart as "custom had decreed, and that each "had much to learn from the other."

Now the Rand has less relationship to metal mining in any other part of the world than it has to coal and ironstone mining wherever these are being extracted from the bowels of the earth, and it would be well for the future of Rand mining if this were more generally recognised and every encouragement given to the carrying out of coal mining practice.

Further, Mr. Marriott says: "Of stoping it may be said that as an art it is dying out."

This is rather a severe statement when we consider that the mining costs on the Rand form such a large proportion of the total costs, and every effort should be made from the management down to the native drill boy to resuscitate and perfect this dying art.

His further remarks show how this may be done, where he says:

> "The best that can be done to-day is "to divide the work between several "skilled supervisors, each of whom has "sufficient time to keep continually in "touch with every one of the stopes "allotted to him. It would be his "particular business to learn the "characteristics of the ground to be "broken and to vary the system "employed when by so doing an in-"creased profit is shown by trial to be "obtainable."

In order to get the full benefit of coal mining practice the lay-out must be carefully considered, and some improvements has already been gained by laying-out the main levels in the foot-wall and taking out all the reef in the stopes without leaving any solid pillars. This has led to straighter drives and better haulage ways, but much has yet to be accomplished in stoping and breaking ground, and in the regularity with which pack-walls and pigstyes are built so as to enable stope-haulage to be conducted in a more general manner than at present, and in arriving at the best angle of dip to maintain the face so as to obtain the largest tonnage per shift, by taking full advantage of the hanging-wall pressures without endangering the safety of the workmen in the stope.

There is much more in mining than in simply drilling and blasting, and the heavier pressure now being felt in the deeper mines is bringing this home to all concerned, and this paper by Mr. Chilton should encourage others to bring forward papers descriptive of practical work with the experience gained thereby, as only by comparing notes in this way will the dying art of mining, as hinted at by Mr. Marriott, be revived and the future mining of the gold reefs be made more profitable.

The author speaks of the danger of creep and crush in the Eastern gold mines of the Rand, where there is a soft slate foot-wall, and there is no doubt that if no pillars were left at all, and compressible pack-walls were built, these pack-walls would so relieve the pressure on the foot-wall that creep and crush would be eliminated.

It is the solid pillars left in the mine that is the cause of creep and crush, and in deep mines the enormous size of the pillars necessary to prevent the effect of creep or crush can hardly be estimated, therefore where main haulages are to be kept open during the life of the mine they had better be in the foot-wall altogether, or if in the plane of the reef then there should be no solid pillar within 200 ft., and the sides of these roadways should have good pack-walls built systematically along the whole length.

It is better to allow the hanging-wall to come down and settle on the pack-walls when after a time there will be no further movements, than to be having continual bursts at various points and probably a total collapse of a considerable area, or the continual upheaval of the foot-wall along the whole roadway.

Mr. I. Hodges *(Member)*: There is a growing tendency in coal mining to dispense with shaft pillars. Many of the deepest mines now are starting work direct from the pit mouth, and in some of the deep mines where shaft pillars were left they have had to be removed in order to keep weight and crush from the shaft. The enormous areas required for shaft pillars as one gets to great depths is a deterrent, and they have so little real advantage that many coal mines have come to the conclusion that it is better to remove the coal and build packs, let them get their weight on, and deal with any slight crush they may have in the shaft in the first stages of the mine so as to have no further trouble. I am very interested in this question of the advantage which would

occur to managers of gold mines from a more general appreciation of the effect of weight and conditions under which this is applied in coal mining at great depths compared with gold.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Potash from Cement Plants.—"A source of potash which is likely to become an important one, is now being exploited in American cement works, consisting in the recovery of potassium sulphate from the dust arising from the kilns. Clays and shales used in cement manufacture frequently contain as high as 2·5% of K_2O, and by suitable means this potash can be volatilised and collected in the kiln dust, from which it may be extracted by leaching.

At the Riverside Portland Cement Works, California, it has been found possible to recover 60% of the potash contained in the raw materials, the product being worth about 2/- per barrel of clinker.

In order to render the potash more volatile an addition of 0·8% of calcium fluoride is made to the raw mix for every 1% of potash contained therein. At a temperature of 1,100°, potassium fluoride is liberated, and passes away with the dust. This compound is converted into potassium sulphate by reaction with sulphurous gases, calcium fluoride being again produced in the dust. Considerable improvements have been effected in dust collection by adopting the Cottrell electric dust precipitator, by means of which 80% of the potash volatilised is precipitated as dust.

The potash exists in the dust largely in the form of a double salt of potassium and calcium sulphates corresponding to the naturally occurring mineral sygenite. This compound is sparingly soluble in cold water, but by leaching the kiln dust at 85° C., about 95% of the potash is dissolved. The solution is removed by means of filter presses, and the filter cake, containing a large quantity of the calcium fluoride, is returned to the kiln for use in subsequent operations.

The solution is partially evaporated by solar heat, and is finally concentrated by steam coils and the crystals separated. The product is giving success as a material ready for the manufacture of fertilisers."—*Met. and Chem. Eng.*, 1917, XVI., 701.—*Australian Indust. and Mining Standard*, p. 97, Feb. 14, 1918. (E. M. W.)

Basic Slag and Rock Phosphates; Trials on Grassland.—"The results are given for the first two years of a six years' comparative field test of the relative value of low and high citric-soluble phosphates when applied to grass land. A high-grade basic slag, Gafsa rock phosphate, open-hearth basic slag (fluorspar slag, 45% citric-solubility), and two low-grade, high citric-soluble slags were compared on three clay soils. On all three soils the fluorspar slag gave very satisfactory results. On only one soil did the high citric-soluble slag give results appreciably superior to the low citric-soluble phosphate. The author advocates that, as far as possible, open-hearth basic slag should be utilised for improving poor pasture and meadow hay land. Fineness of grinding is essential."—G. S. Robertson, *J. Bd. Agric.*, 1918, *24*, 1077-1086.—*Jour. Soc. Chem. Ind.*, March 15, 1918, p. 132A. (A. W.)

Distillation of Lignite.—"Efforts are being made in France to introduce the distillation of lignite for tars. According to a recent article in *La Nature* the Société de Distillation des Combustibles, Paris, is constructing an improved Ziegler type of furnace similar to that used for the distillation of peat, a type yielding about 7% of tar, which is treated by fractional distillations carried out in vacuo, to increase the output of heavy products; followed by chemical purification by washing with dilute sulphuric acid and soda, to remove the picolines, cresols, etc. The crude paraffin, extracted by crystallisation of the heaviest oils, is first passed through the filter-press. The purification consists of a series of filterings in the filter-press, and meltings in light oil. The last traces of oil are removed by scrubbing with super-heated steam, and the paraffin wax is clarified by filtering through animal black. In one place in Germany, where the system was adopted, 70 to 80% of marketable products were obtained from lignite tar, viz., 15 to 20% of paraffin wax; 5 to 20% of kerosene; 5 to 15% of creosotes and organic acids; the remainder being light products, petrol, etc., or heavy products such as gas oils and lubricating oils."—*Indian Engineering*, March 23, 1918, p. 163. (J. A. W.)

Detection of Selenium in Sulphuric Acid.—"If a small crystal of aspidospermine is added to a few drops of sulphuric acid containing selenium, and the mixture then heated until fumes appear, the crystal, and afterwards the whole mixture, is coloured an intense violet. A coloration is not obtained in the absence of selenium, but a red coloration develops if the acid contains an oxidizing substance such as lead peroxide or potassium chlorate.—L. P. J. Palet, *Ann. Chim. Analyt.*, 1918, *23*, 25-26.—*Jour. Soc. Chem. Ind.*, March 30, p. 147A. (A. W.)

Pulverised Coal.—The use of pulverised coal is spreading in the United States. According to a pamphlet by Mr. H. G. Barnhurst, of the Fuller Engineering Company, Allentown, Pennsylvania, the quantities used annually in various manufactures are as follows:—In the cement industry, 6,000,000 tons; in the steel and iron industry, 2,000,000 tons; in the production of copper, 1,500,000 tons; and in the generation of power, 100,000 tons to 200,000 tons. To attain success the coal must be dried, crushed and pulverised until 95 per cent. will pass through a 100 mesh sieve, having 10,000 openings to the square inch. A cubic inch will contain over 200,000,000 particles, none of which will be greater than one-hundredth of an inch cube, and a large percentage less than one six hundredth of an inch cube. So far pulverised coal has not made much progress for steam raising, as considerable expert knowledge is required to obtain satisfactory results. However, there are some installations, and the Puget Sound Traction, Light and Power Company is putting down an equipment for operating a battery of Babcock and

Wilcox boilers equalling 4,100 rated boiler horse-power at 200% rating." *Indian Engineering*, April 6, 1918, p. 191. (J. A. W.)

Determination of Non-Sulphide Copper.—"The method is applicable to the determination of oxidised copper ores and native copper in presence of sulphide ores. It depends on the solution of the oxidised copper in sulphurous acid. The sample must be very finely powdered and thoroughly agitated with the sulphurous acid solution for at least half-an-hour. After this treatment, the residues filtered off and washed with water containing sulphur dioxide in solution. For most purposes a 3% solution of sulphurous acid is most effective and it is most conveniently prepared from the liquid sulphur dioxide supplied in steel cylinders. The copper in the filtrate may be determined electrolytically or otherwise. It is stated that copper sulphides are quite unattacked by this treatment."—*Mining and Scientific Press*, March 9, 1918, pp. 339–340. (H. R. A.)

Separation of Copper from Arsenic, etc.—"The mixed sulphides are digested with a reagent prepared by saturating a 12% sodium hydroxide solution with hydrogen sulphide and adding to each litre 400 cc. of 40% sodium hydroxide solution. Mercuric, arsenic, antimony, and tin sulphides dissolve, whilst lead, bismuth, copper and cadmium sulphides remain insoluble. The latter are separated by filtration. The filtrate is treated with a quantity of ammonium carbonate sufficient to precipitate the mercury completely, and, after this has been removed, the solution is acidified with hydrochloric acid. The precipitated arsenic, antimony, and tin sulphides are collected, treated with 20 cc. of concentrated hydrochloric acid, and the mixture is warmed until vigorous evolution of hydrogen sulphide ceases. Arsenic sulphide is not dissolved by this treatment; after the solution containing the tin and antimony sulphides has been separated, the arsenic sulphide is dissolved in ammonia and the solution neutralised with nitric acid; a yellow precipitate forms which is dissolved by boiling with nitric acid, and the solution is treated at 85° C. with an excess of ammonium molybdate. With a large amount of arsenic, a yellow precipitate forms at once, but with traces half an hour's heating may be required to obtain a precipitate."—M. C. Sneed, *J. Amer. Chem. Soc.*, 1918, *40*, 187-191.—*Journal of the Society of Chemical Industry*, March 30, 1918, p. 168a. (A. W.)

Separation of Nickel and Copper by Means of Dimethylglyoxime.—"Treat the solution containing Ni and Cu with NaK tartrate in quantity sufficient to keep the Cu in solution when the mixture is rendered alkaline, and precipitate the Ni by the addition of 1% alcoholic dimethylglyoxime solution and NH_4OH. Filter, dissolve the precipitate in hot dilute HCl, and reprecipitate the Ni by the addition of NaK tartrate, dimethylglyoxime and NH_4OH. Then precipitate the Cu as sulphide from the filtrates."—H. Grossmann and J. Mannheim, *Z. angew. Chem.*, *30*, I., 159-60 (1917); *J. Chem. Soc.*, *112*, II., 512.—*Chemical Abstracts*, April 10, 1918, p. 658. (J. G.)

Determination of Sulphur in Pyrite.—"About 0·5 gm. of the finely powdered sample is oxidized with nitric and hydrochloric acids, or is fused with a mixture of sodium carbonate and potassium nitrate, and after separation of silica in the usual way, the sulphuric acid is precipitated directly from the hydrochloric acid solution without previously removing the iron. The solution, which should contain from 30 cc. to 50 cc. of 6N hydrochloric acid, is diluted to 700 cc., heated to boiling, and 40 cc. of 10% barium chloride solution diluted with 100 cc. of boiling water is added slowly while the mixture is stirred. After 15 hours, the barium sulphate is collected, washed with water containing hydrochloric acid and barium chloride, then with hot water, dried, ignited, and weighed. Under these conditions, the presence of ferric chloride does not affect the accuracy of the results obtained."—Z. Karaoglanow, and P. and M. Dimitrow, *Z. anal. Chem.*, 1917, *56*, 561-568.—*Jour. Soc. Chem. Ind.*, April 30, 1918, p. 204a. (A. W.)

Determination of Chlorates and Hypochlorites.—"A suitable quantity, *e.g.*, 10 cc. of a solution containing about 0·5% of potassium chlorate and calcium hypochlorite, is diluted to 100 cc. in a large stoppered flask. 2 gm. of potassium iodide is added, the solution is acidified with dilute acetic acid and, after 5 minutes, titrated with thiosulphate solution: this titration gives the amount of hypochlorite. Another portion of 10 cc. of the solution is treated in a stoppered flask with 1 gm. of potassium bromide and 30 cc. of concentrated hydrochloric acid; after 15 minutes, 15·0 cc. of 1% potassium iodide solution is added, the mixture is shaken, and titrated with thiosulphate solution. The difference between the two titrations is a measure of the amount of chlorate present."—E. Rupp, *Z. anal. Chem.*, 1917, *56*, 586-586.—*Jour. Soc. Chem. Ind.*, April 30, 1918, 205a. (A. W.)

Detection of Vanadium.—"A solution of 0·2 gm. of diphenylamine in 100 cc. of water in presence of hydrochloric acid gives a violet coloration with aqueous solutions of vanadium compounds. The coloration is unaffected by the presence of nitrates, iron, or titanates, and the test will detect the presence of vanadates in solutions of 0·0002% strength."—V. L. Meaurio, *Anal. Soc. Quim. Argentina*, 1917, *5*, 185-189.—*Jour. Soc. Chem. Ind.*, April 30, 1918, p. 221a. (A. W.)

METALLURGY.

Electric Zinc in Utah.—"The process used by the Judge Mining and Smelting Company, Park City, Utah, for the production of electrolytic zinc is as follows:—The zinc concentrates produced at the company's concentrator contain some lead and silver. They are treated first in a Wedge roasting furnace. The roasted ore is then leached by agitation with an 8% sulphuric acid solution in Deveroux vats. The leach-vat product is discharged to classifiers for the removal of the coarse insoluble material. The solution and fine suspended solids which flow from the classifier are treated in a Dorr thickener, the under-flow from which is sent to an Oliver filter. The coarse and fine solids thus recovered from the classifier and filter are sold to lead smelters for the recovery of lead and silver. The leach liquor contains impurities in the form of copper and cadmium which are dissolved from the ore, and these are removed before the zinc is recovered. The removal of impurities is accomplished by passing the liquor through tube mills filled with

zinc shot on which the copper and other metals are precipitated in spongy form. The solution flowing from the tube mills is filtered, and is then ready for treatment in the electrolytic cells. The cell room contains 120 cells arranged in two groups of 60 each. Each group is served by a generator delivering 5,000 amperes at 250 volts. Each cell carries 12 aluminium discs, 5 ft. in diameter, mounted on a rotating shaft. Alternating with the aluminium cathodes are 13 lead anodes, which are supported independently of the shaft. Zinc is deposited on the rotating cathodes, and in the course of about three weeks each cell of 12 discs collects about 5,000 lb. of zinc. The loaded shaft is removed, the zinc stripped and the shaft reassembled for return to the cell. The electrolytic zinc is melted, into cast cakes and marketed. The electrolyte is again used in leaching roasted ore."—C. A. Hansen.—*Indian Engineering*, Feb. 23, 1918, p. 107. (J. A. W.)

Titanium in Steel Production.—"The use to which titanium is put is in the removal of nitrogen from steel because nitrogen tends to make steel brittle and favours the segregation of phosphorus and sulphur in the steel. At a temperature of 800° C. titanium combines with nitrogen to form titanium nitrides, which may be removed leaving the steel free of this element. The pure titanium cannot be used for this purpose on account of its low melting point and low specific gravity; therefore among other combinations, what is employed as the best is an alloy of titanium and iron in which the percentage of titanium ranges from 10 to 15, and known as ferro-titanium. One-half per cent. of this alloy, that is, only 1·7 lb. of titanium per ton of steel produced is sufficient; it will keep the steel ductile, prevent segregation of the sulphur, phosphorus and carbon, concentrate the blow-holes in the pipe cavity, and improve the working of the steel in the rolling mill. The alloy is added just as the steel runs into the ladle, when on instantaneous reaction occurs and after a short time the slag formed by the reaction (chiefly titanic oxide) rises to the surface. It is thus a valuable element in the production of steel rails, particularly the rails laid in position where wear is excessive, the loss by abrasion being only one-third of that in Bessemer rails. It must be noted, however, that open-hearth steel does not appear to benefit as much by treatment with ferro-titanium as Bessemer steel does. Steel bars treated with it show increased strength and an improved structure of a fibrous texture similar to that of forged iron. Titanium also improves copper castings; if 4% to 1% of an alloy of copper and titanium containing from 5% to 12% of titanium be added to molten copper, it can be cast in sand without difficulty, absorbed gases and oxide are eliminated and the metal is given a close-grained dense structure free from blow-holes. Added to aluminium bronze it makes it equal to a phosphor or manganese bronze in strength. In the form of 'titanium thermit,' which is a finely powdered mixture of metallic aluminium and oxides of titanium and iron, it is enclosed in a tin and introduced into the ladle for the same purpose and with the same results as ferro-titanium. Pure titanium, which has a melting point of about 1,850° C. and a specific gravity of 5·17, does not appear to have been put to any industrial use.

Iron ores containing titanium are not easy to smelt, nor is the product of good quality. The slag is pasty, larger quantities of fuel are consumed and aggregations occur, of titanium nitride and nitrocyanide in the furnace which make working difficult. Many attempts have, however, been made to utilise such ores, but with varying success. For example, in 1914 an attempt was made to utilise the Sanford Hill ore which consists approximately of two-thirds ilmenite (a titanium ore) and one-third magnetite. By special treatment a concentrate was obtained containing about 55% of iron and 11½% of titanium. This was smelted in a blast furnace with magnetite in proportions varying from 1/16th to 5/16th of the total charge and in the result it was found both that the slag was quite fluid and the consumption of fuel normal. With small percentages of titanium in iron ore, say, 7% or 8%, fairly good results have been obtained, more especially in the electric furnace, and as there are in existence enormous quantities of such ores a good field is offered for developing commercial methods of utilising them. Titanium carbide has been used to a small extent as an electrode for arc lighting; the light is of high candle-power but is yellow in colour and expensive. Titanium has also been tried in a limited way as a filament in electric glow lamps and is said to give a high candle-power efficiency and to be less sensitive to variations in voltage than other filaments. The ore has been used in minor ways also, such as for the production of pigments, for giving a soft yellow colour to glazed tiles and in the manufacture of artificial teeth. Its salts are sometimes used as a mordant for textiles and in the form of titanium potassium oxalate it is used on a fair scale for staining and dyeing leather.

Though not found in the metallic form in nature, the dioxide (TiO_2) is very widely distributed in two forms, rutile and ilmenite. Rutile occurs in masses in various rocks, its colour ranges from yellow to reddish brown or black and it contains 98% to 99% of titanic oxide and 1% to 2% of ferric oxide. Ilmenite or titaniferous iron ore is an iron black mineral occurring massive or in the form of thin plates or grains. It contains 51·7% of titanic oxide and 47·3% of ferrous oxide. Among countries where titanium is utilised to any extent are Norway producing mostly rutile and Canada producing mostly ilmenite. In the United States both rutile and ilmenite are mined but to a small extent only. India and Ceylon produce ilmenite from what are known as monazite sands occurring so far as India is concerned, chiefly in Travancore. The Gold Coast, Nigeria, Nyasaland, Queensland, S. Australia, W. Australia and Tasmania, are also producing countries."—*Indian Engineering*, Feb. 2, 1918, p. 68. (J. A. W.)

Composition of Portland Cement.—"Portland cement consists essentially of a mixture of lime and silicate of almumina which has been burned to a temperature of about 1,500 deg. C., the proportion being 1·7 parts by weight of lime to 1 part of silica plus alumina (and iron). Since its discovery speculation has always been rife amongst chemists as to its chemical composition, and it might be expected that a true explanation of this problem would be of great value in fixing the most favourable conditions for its manufacture. Until recent years, however, the tendency had been to regard the matter too closely from the point of view of chemical equations, the physical side of the question being almost entirely overlooked.

Of the compounds likely to be formed, tricalcic

silicate, dicalcic silicate, and tricalcic aluminate have been considered the most important, and, according to Chatelier, the cement forming properties are due to the presence of the first named.

With the development of the phase rule and the assistance which the study of cooling curves and microstructure has afforded in attacking problems associated with reactions which go on when different substances are melted together, due allowance is now being made for considerations of physical character. Thus it is now understood that although a compound exists having an empirical formula represented by AB, we may have to reckon with solid solutions of AB dissolved in A, A dissolved in AB, and also AB dissolved in B, and B dissolved in AB, whilst at the same time we may have eutectic mixtures of pairs of these solid solutions. Certain other considerations may be involved if at a definite temperature the compound AB undergoes decomposition or dissociation.

Each of these principles must be allowed for with further complications when we are dealing with a system comprising three constituents such as tricalcic silicate, dicalcic silicate, and tricalcic aluminate.

At the Carnegie Institution, Washington, this aspect of the subject has been studied in a very comprehensive manner, and Rankin has described the results of the researches carried out in connection with which no less than 1,000 different mixtures were examined. The work goes to show that tricalcic silicate is the constituent which hardens and gives the greatest strength within a reasonable time, but that in an average Portland cement this constituent only exists to the extent of 30% to 35%. In order to determine the most economical means whereby this constituent may be produced in the largest proportion, it will be necessary to study the rate of formation of this constituent in a series of mixtures and the conditions of equilibrium of such mixtures at high temperatures.

In the experiments made the mixtures were all fused in the electric furnace, and consequently it may be assumed that complete equilibrium was obtained in each case. In actual practice the materials never reach this stage, since they are only heated to a temperature which causes sintering or incipient fusion to take place.

Under such conditions it is to be expected that in the case of the coarser particles, mainly limestones, the conditions existing near the surface will correspond to an equilibrium in which alumina and silica will be in excess, whilst in the interior the converse will be the case. It may thus be seen what an enormously complicated problem the study of the composition of Portland cement really is and what a vast field of research still awaits elucidation by investigators equipped with modern appliances and proper methods."—*Australian Industrial and Mining Standard*, Feb. 21, 1918, p. 120. (E. M. W.)

MINING.

Sampling Mine Floors.—"Sampling mine floors is hard and unpleasant work, and because of inaccuracies involved is to be avoided where the necessary samples can be obtained from the walls or roof. In floor sampling it is difficult to catch all the fine and keep the sample free from mud or other floor material, to which is added the impossibility of inspecting the vein carefully before sampling without, in some cases, a prohibitive amount of preliminary work. Further difficulties not involved in sampling walls or roof are: Diversion of water flow, removal of loose floor material, tearing up and relaying of track, and sometimes the additional hardships attendant on the necessity of doing the work without interference with regular mine operations.

Conditions where floor sampling is necessary.—Workings to be sampled may be classified under two heads, dry and wet. The difficulties and inaccuracies involved in the latter are much greater than in dry mines. By the term "sampling" is meant cutting the ore by hammer and moil.

In dry mines the chief difficulties are those arising from catching flying sample particles, removing track and loose floor material, and, in a mine in operation, conducting the floor sampling without interfering with regular work. The only chances for error involved in sampling a dry floor are in catching all the flying particles, gathering the line from the bottom of the cut, and preventing extraneous floor material from rolling into it. Catching flying particles is not nearly so difficult in roof or wall sampling, as the particles fly in a general downward direction and can be caught in a box or canvas basket held close to the point of cutting, or by a large canvas spread on the floor; although with the best precautions many pieces fly astray. In sampling floors, the chips fly upward and outward in every direction. To catch these, it is best to place one canvas across the line of cut, just ahead of the point of cutting, and one on each side of the cut. If a deep preparatory trench has to be cut through loose rock on the floor, it should be made wide enough to keep extraneous material from rolling into the sample groove, and the canvas should be pressed down into the trench ahead of the point of cutting. A box held a foot or so above the moil and just ahead of that point will act as a baffle, preventing the particles from flying too far and causing them to fall back upon the canvas. When one-half the sample has been taken, the canvas should be laid on the other side, and the second half of the cut made, always keeping the canvas close up to the point of cutting. A stiff brush will be necessary to aid in gathering up all the fine.

Water control in floor sampling.—In addition to the difficulties already enumerated, in wet mines mud and water must be overcome. In the first place, the main flow of water must be bypassed, so as to make sampling at all possible, and, secondly, seepage must be minimised in order not to contaminate the sample with mud.

Obviously, in sampling the floor of a wet mine, handling the water is the chief problem, and the accuracy of the work will depend upon the precautions taken. In the preliminary sampling of a small property, it would be too costly to take all the precautions that might be enumerated. In such a case, where the vein is narrower than the drift, the water can be run through a ditch at one side of the drift, or if the vein is too wide to permit this, the water can be passed across each trench in the loose floor much by means of a launder or piece of air pipe a few feet in length. In this way, by bailing out the seepage a few times while moiling is in progress, it is possible to get a sample with the least expenditure of time and effort. The sample, it is true, will be somewhat subject to inaccuracies, either on account of mud carried into the cuttings, or, if the cuttings are

washed free from mud, by the loss of fine. This is a makeshift method, and justifiable only on a preliminary examination where the necessity for greatest accuracy does not warrant expenditure of more time and money.

In more important examinations, greater care must be taken. If the water in a drift comes from one or a few chief sources, down certain raises or chutes, for example, it can be carried past the working point in launders or pipes. If this is done a day or so before the sampling is started, the loose floor material will have drained to such an extent that seepage into the trenches will be little. On the other hand, if the water comes from a general percolation through the vein, the use of dams must be resorted to in order to collect it, and launders or pipe used to carry off the water from behind the dams. If a level is extemely wet, a dam will have to be built for each short length of drift sampled. For example, beginning at the lowest point of a level, which would be (or should be) where it connects with a shaft, crosscut, or other main working, a dam should be built across the drift about 100 ft. distant. This dam can be easily made with a couple of 2×12 in. planks, superimposed edgewise, and fitting snugly against the floor and walls. It should be made as nearly water-tight as possible by calking, or tamped with clay, cement, talc, or any fine-grained impervious material. The launder or pipe should lead from the upper half. The dam should be only high enough to give a slight grade to the launder with enough elevation to carry it over irregularities in the floor. If the dam is too high, the hydraulic pressure will be such as to cause water to leak through so crude a structure.

With the dam in place, the main flow of water is cut off, and trench digging and sample cutting can proceed. If the inflow of water along the vein is large, it may be necessary to have the dam quite close to the point of cutting, for otherwise the trench may fill with water so fast as to require constant bailing. The seepage into a trench may sometimes be greatly lessened by digging auxiliary trenches above the sample trench, and bailing from them. In some cases, the removal of all loose floor material, instead of just digging trenches, may be necessary to prevent too great an infiltration of mud into the sample cut.

Comparative advantages of pipe and flume.—The methods of conducting water flow are by pipe and flume. Each system possesses advantages not to be found in the other, the greatest advantage being in favour of the flume, especially under certain conditions, which will be described. Light, galvanised-iron air pipe is easier to handle and put together, and in a straight drift with no branch opening, conducting tributary water, is to be preferred to a flume, if the material is immediately available. The flume, while heavier than the pipe, and more trouble to put together, has the following advantages:—It can be cut up into short lengths in order to make turns; it is open at the top and can be bailed into, which is a great advantage when more than one cut is being made at the same time, as the bailed water is conducted away instead of running down into the next lower cut; and if a crosscut is adding water to the flow in the drift, a second cut can be built across it at the intersection, and a short flume used to carry the water collected into the main flume.

Catching the cuttings is the chief difficulty in sampling wet floors. A canvas cannot be spread over the floor and down into the sample trench as with dry floors, because the seepage would carry upon it a great deal of mud. Some engineers suggest washing the sample to eliminate this infiltrated mud, but that would cause a loss of fine from the cuttings as well. The best way to catch the cuttings is to hold a canvas sampling bucket, or a conical "butterfly-net" sample catches, close to the bottom of the trench and a few inches in advance of the moil point, with the opening of the receptacle in a vertical position. The circular shape of the bucket opening permits either to get closer to the floor in the bottom of the trench than is possible with a box.

Two other errors are involved in sampling wet floors. One, the obscuring of the work by dirty seepage, making it impossible to be sure that a uniform cut is being taken; the other, the concentration of rich fine into floor cracks by the action of running water, causing high assay samples. The first cause of trouble has been dealt with; the second can be guarded against by making a preliminary cut across the vein and rejecting the material before making the regular sample cut. If error from this source is expected, the rejects from a few preliminary cuts should be assayed with the regular sample cuts as a check or confirmation, before going to the trouble of making further double cuts."—A. G. Wolf, *Eng. and Min. Journal.—Queensland Govt. Mining Journal*, April 15, 1918, p. 166. (H. A. W.)

MISCELLANEOUS.

A New Process of Colour Photography.—"According to *La Nature*, a new method for colour photography has been devised by Mr. L. Dufay, who is associated with the Lumiére firm. The difficulty hitherto has been to get coloured lines in sufficiently close juxtaposition and of the requisite fineness. This is stated to have now been completely overcome. A thin celluloid film is passed between two warmed rollers bearing fine grooves on their surface, similar fine grooves being thus found on the celluloid. The film is coated with a transparent coloured adhesive material, wiped and then treated with an alcoholic solution of another colour, which enters the exposed surface of the celluloid. Two adjacent lines of different colours are thus formed, which may be as fine as one-thirtieth of a millimetre. The other side of the film may be similarly treated with the other colours. Three double pairs of colours: (1) yellow and blue, red and green, (2) yellow and red, blue and orange, (3) red and blue, yellow and violet, are suggested."—R. Dufay, *Ind. Engineering*, March 9, 1918, p. 135. (J. A. W.)

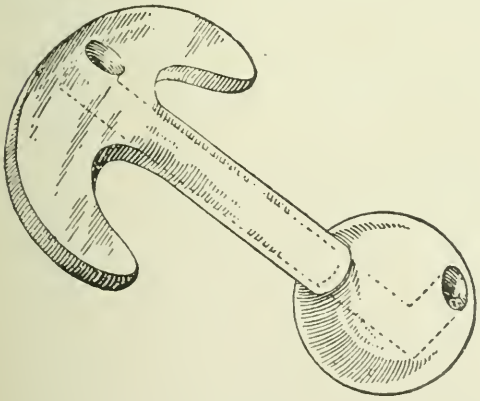
Phosphate in Egypt.—"Phosphate occurs in many places in Upper Egypt, along the Nile Valley, principally on the right side, and also near the Red Sea coast. Upon rocks like granite, serpentine, porphyry, and diabase comes the Cretaceous formation, containing considerable quantities of phosphate, at Gebel Duwi, Gebel Nakheil, and Gebel Korseir El Kadim, not far from the coast. More to the north, in the hills near Safaga bay, is another rich bed. Phosphate is said to exist near Suez and in the Sinai peninsula. The formation in Egypt is variable, not only from place to place, but even within small areas. The mines are well developed on the right bank of the Nile at Sharawna and along the Red Sea coast, at Safaga

and near Kosseir. The uppermost bed of the Sharawna formation is a hard limestone, 1½ ft to 4 ft. thick, made up entirely of oyster shells, strongly cemented by carbonate of lime. In places this changes into a true phosphatic bed; the oyster shells disappear little by little, the rock becomes softer, granulated, and in less than 1,000 ft. the hard bed is transformed into fine tricalcic phosphate, assaying as high as 63%. Occasionally, the phosphate, instead of replacing the oyster bed, spreads underneath and reaches a thickness of 2·3 ft. and a percentage of 60; in other places it is 6½ ft. or more, is very hard, full of small coprolites, but is not above 25% to 35%.

The Sebaïeh phosphate is already on the market, raw or ground. In parts of the desert it is estimated that there are 50 million tons of phosphate. Immense quantities of relatively low-grade material are available."—E. Cortese.—*Mining and Scientific Press*, March 16, 1918, p. 374. (H. R. A.)

Ear Protector for Millmen.—"Many millmen protect their ears by stuffing them full of cotton and soap, or even waste. For a number of years I have used the ordinary naval big gun ear protectors, when working in a mill, and find the form herein illustrated the safest and most comfortable; and while they do not prevent one's ears from ringing for a while after removing the protectors they do furnish a great relief, especially for those who are not continuously in the mill, and whose ears therefore do not get adjusted to the vibration.

The protector is made of celluloid, and consists essentially of a ball containing a round hole on one side, and a small duct leading from the bottom of the hole through the stem to another smaller hole in the anchor-shaped terminus of the stem. The ball is inserted in the ear, the hole next to



the ear drum, and the anchor-shaped stem is braced against the lobe of the ear, thus holding the protector in place. The sound now has to enter the small hole in the stem, traverse the narrow passage or duct to the hole in the ball, and thence pass to the drum of the ear. The sound therefore has to pass through a decreased aperture and make two sharp bends before reaching the ear; the effect is to reduce the shock and vibration to the ear drum without preventing one from hearing entirely.

There is nothing in the shape or method of insertion of this protector to injure the ear in any way.—S. H. Brockunier, *Mining and Scientific Press.—Queensland Govt. Min. Journal*, April 15, 1918, p. 161. (H. A. W.)

Abstracts of Patent Applications.

427.17. C. Hosking. A rope grip for mechanical haulage. 24.7.17.

This application is for a rope grip for mechanical haulage purposes, the jaws of the grip being shaped at the bottom to suit the size of rope required and made wider at the top to easily admit the rope, and so formed that the swing of the arms due to the pull of the rope causes them to overlap the rope on its upper surface, thereby causing the grip to be in contact with the rope round its whole surface.

Two grips are illustrated and described, one designed to work in both directions and one in one direction only.

491.17. M. O. Cranston. Improvements in reinforced concrete for the manufacture of mine props, telescopic bars for the erection of mine props underground, cyanide vats, a combined wastepack and pigstye mine pole. 20.8.17.

This application deals with reinforced concrete sectional cylindrical mine props. The specification describes sectional cylinders made of various diameters and 6 in. in height with a female fitting of certain dimensions in diameter at one end and a male fitting of smaller diameter at the other end. All the reinforcements are of a spiral shape being about ½ in. apart. The horizontal strands are about 1 in. apart and contain two strands which are twisted in order to hold spiral firmly in shape. The sectional cylinders are thus reinforced using larger or smaller wire, and varying number of strands. The design of frame is dependent upon the required strength. The diameter of these cylinders may be increased or decreased dependent upon the required strength.

493.17. W. R. Hume. Improvements in and connected with the jointing of concrete pipes and means for effecting the same. 20.8.17.

This application refers to improvements in and connected with the jointing of concrete pipes and the materials necessary for making the plastic joint for fairly high pressures.

509.17. W. G. Gibson. A machine for scraping and dressing battery plates and the like. 29.8.17.

This application is for a hand operated mechanical device for dressing and for scraping amalgam plates. The device consists of a shaft stretching across the plate, to which adjustable scrapers, brushes and a mercury container are fastened. By a forward and backward movement of a crank fastened at each end of the shaft the scrapers or the brushes are caused to operate on the amalgam or on the amalgam plate surface. Longitudinal movement up and down the plate is provided for by rollers running in a recessed track.

594.17. J. R. Williams. Improvements in the treatment of earthy matter containing valuable salts. 4.10.17.

This application relates to a process for the preliminary treatment of natural deposits consisting of valuable salts, colloidal and earthy matter, gelatinous silica and humus.

631.17. S. L. Berry. Improvements in metallurgical agitators. 17.10.17.

This application relates to improvements in agitators which consists in providing, in a vat a rotatable pump casing with hollow arms extending radially, with separate means for rotating this structure as well as the internal impeller of the pump casing at varying speeds, or directions.

The object of the invention is to provide a mechanically driven agitator in which the jets issue in the direction of its rotation, and may be used also as an amalgamator.

686.17. W. B. Vanderlip. Improvements in and relating to ore concentrating machines. 5.11.17.

This application is for a batea shaped concentrating pan, which also acts as an amalgamator. The machine consists of a batea or pan to which is imparted a vanning motion by means of eccentrics, which act upon the underside of the pan. Concentrates are drawn off positively at the centre by means of a variable speed vertical screw conveyor, which also seals this centre opening to the discharge of tailing. The tailing discharges circumferentially into an overflow launder. Riffles may be placed in the basin of the pan, as desired; amalgamating plates may also be placed in the basin. The application covers the use of screw conveyors working in troughs placed across the travel of the concentrate, as, for instance, on a reciprocating concentrator deck, for the purpose of effecting a positive concentrate discharge.

702.17. H. R. Ives. Improvements in jockeys or rope grips for mechanical haulages and the like. 10.11.17.

This application refers to a form of jockey or grip for rope haulages.

The principal feature is the employment of two eccentric cams provided with vertical grooves to produce a gripping surface, or alternatively, with a horizontal groove in which the rope is held.

The cams are provided with a toothed segment in the lower portion of each, which segments engage with each other and thus secure simultaneous movement of the gripping surfaces.

The principal claim is: "A jockey or rope grip for mechanical haulages and the like, comprising a pair of opposing cams or eccentric pieces between which the rope is gripped, and means independent of the rope, whereby the rotary motion of either of them is transmitted to the other, substantially as and for the purpose described."

718.17. J. B. Eder (1), British Agencies, Ltd. (2). Improvements in mine and like electric bells. 16.11.17.

The particular bell described is the enclosed type in which the gong is mounted over the casing which contains the actuating mechanism, with its hammer and stem outside the casing and inside the gong. The particular features of this bell are:

First.—That the armature is rigidly secured to a vertical spindle which is pivoted at its lower end on the bottom of the casing, the spindle projecting beyond the casing, and on this projection the hammer stem is mounted; and

Second.—The use of an electro-magnet consisting of one coil instead of two as generally used, and having end pole pieces and lateral pole faces presented to the armature.

747.17. D. S. O'Donovan. Improvements in presses or means for drying or filtering sludge or similar thick mixtures of solids and liquids. 23.11.17.

This application is for an improvement in presses for dewatering sludge, more particularly sludge dealt with in underground workings.

The apparatus described is a press consisting of a perforated cylinder (for instance, a large pipe), on the outside of which filter media of canvas and jute are wound. This filter is secured in position by longitudinal perforated and grooved wooden lagging clamped with iron clamps. One end of the pipe filter serves as the pulp inlet; to the other end is fastened a swinging door through which discharge of the dewatered sludge is effected. In operation, sludge is pressed into the pipe filter by means of a pump or a static head and the solid particles gradually pressing closely together, express the moisture. The cake of sludge is then pulled out by means of a boring tool operated by hand.

782.17. J. Peterson. Improvements in power generating and power transmitting mechanism. 10.12.17.

This application relates to improvements in power generating and power transmitting mechanism, a primary object being to provide means for applying initial power to a prime motor and by a system of levers and gears to multiply this initial power.

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ol. XIX. OCTOBER 1918. No 4.

NOTICE.

Owing to the Influenza Epidemic, and on the recommendation of the Medical Officer of Health, the usual Monthly Meeting was not held in October. The next Ordinary General Meeting will be held on Saturday, the 16th November.

THE EFFECTS OF DUST INHALATION

By J. S. HALDANE, M.D., F.R.S.
(Hon. Member).

(Printed in Journal, July, 1918.)

Abstract of Discussion at a General Meeting of the Institution of Mining Engineers held at Burlington House, London, W., on the 13th June, 1918, Sir Wm. Garforth (Past-President of the Institution) in the Chair.*

The Chairman (Sir William Garforth) said that the great value of Dr. Haldane's paper lay in the fact that it was founded on practical and scientific knowledge. For many years he had been in close association with Dr. Haldane, and he knew the trouble he had taken in discussing the question with mining engineers, colliery managers, and workmen who had been working in stone or shale-dust for forty years, and in that way Dr. Haldane had acquired a large amount of practical information.

Sir Henry Cunynghame, K.C.B. said that now, after some years, they had apparently a new light thrown upon it by Dr. Haldane. If the particles of dangerous silica were accompanied by other particles which the lungs did not like, the lungs said: "Well, silica, we could not get rid of you, but we have this other stuff, and we will clear that out, silica and all." He put it to the author whether upon the whole that was not a broad way of dealing with what he had proposed, and very likely true. The paper seemed to him to lend itself to speculation possibly of a much wider kind than the author had indicated, because it at once struck one that if by stimulating the lungs with something besides the silica one could cause them to make an effort and throw silica and everything else off, might not there be certain medical vapours which if inhaled into the lungs would enable people to get rid of the silica they had in the lungs already, or get rid of the microbes of pneumonia and other diseases? It was a matter which might well become the subject of experiment, because the idea was very fertile in suggestion. It was quite in accordance with the right medical views, which showed that all modern medicine tended in the direction rather of assisting Nature to do her work than, by some kind of mechanical means, endeavouring to do it for her. Here one cheated Nature a little into getting rid of these objectionable silica particles, and it might be that instead of making innocent tests with silica they might succeed in getting drugs. The author would tell them whether that was possible. He (Sir Henry) referred to drugs of some kind which would stimulate the lungs into making that daily effort which certainly was made. There was no doubt the lungs did it somehow, but they might be stimulated to do it to a further degree, and so get rid of the silica.

Sir Henry Hall, I.S.O. wrote that Dr. Haldane had evidently found great difficulty in reconciling the views he had hitherto held with regard to the injurious effect of inhaling stone-dust containing silica, etc., with the results of recent experiments made by himself and others. The author had sub-

* See *Trans. Instn. of Mining Engineers*, Vol. LV., part 4. Aug.-Sept., 1918, pp. 273—293.

mitted as the practical result of his enquiry that inhaling pure or almost pure quartz-dust was very injurious; especially was this found to be so in the Transvaal and some other gold-mining districts; but that where quartz-dust only formed a part—maybe a considerable part—of the mixture, it might be almost disregarded; and he was able to state that such dust as was usually met with in coal-mines was practically harmless. Dr. Haldane had been driven to this last conclusion by the fact that coal-miners were shown by statistics to have excellent health and apparently suffered no ill-effects from their dusty occupation.

The writer entirely agreed with Dr. Haldane that up to the present coal-miners were a healthy class of men, but he thought that time and experience were required to show whether the present fashion of adding large quantities of stone-dust to the natural dust already on the roads of mines would have an injurious effect on their health. It appeared undesirable to add to the nuisance of dusty roads in this way, and unless we could satisfy ourselves that stone-dusting the roads was a reliable safeguard against firedamp explosions developing into great disasters, it would be foolish to adopt such a course.

Dr. E. L. Collis wrote that the evidence to which Dr. Haldane had alluded (some of which the writer had had the privilege of preparing) as having been placed before the Royal Commission on Metalliferous Mines and Quarries had established at once the danger attached to the inhalation of certain dusts and the comparatively innocuous nature of other dusts. Dr. Haldane had himself supplied the clue which through investigation of the mortality of flint-knappers (the first investigation of mortality associated with exposure to a pure dust) demonstrated the particularly harmful nature of the fine dust of crystalline silica. Following up this clue, the mortality among those exposed to inhalation was found to vary directly with (*a*) the amount of pure silica in the dust and (*b*) the amount of exposure to this dust. Thus, granite-dust, which was composed of about one-third part of silica, was found to be associated with a lower mortality rate than that among sandstone masons and others associated with exposure to sandstone-dust; and, further, no proof could be obtained that fibroid phthisis occurred among any persons exposed to the inhalation of a dust which did not contain pure silica. For the moment the problem then seemed clear, but subsequent enquiries had raised most interesting questions. Thus, as Dr. Haldane had pointed out, Altofts shale, with a much higher percentage of silica than granite-dust, was not associated with the phthisis mortality rate of those exposed to its inhalation.

The dust of ganister, which is a pure form of silica, was found to cause a fearful mortality among those inhaling it either in the mines or in the brick-yards; yet this mortality was profoundly modified—at any rate, among the makers of bricks—if the ganister was mixed with fireclay. In this industry there was no stepping-stone between the terrible mortality among the men who made ganister bricks which were bonded together with lime and the mortality but little different from the normal among those men who made ganister bricks bonded together with clay. Clay then seemed for the moment to possess the power of inhibiting the influence of silica. Further thought, however, showed that potters exposed to flint-dust suffered whether this flint was mixed or unmixed with pottery clay, thus suggesting that there must be some difference between fireclay and pottery clay in the inhibitory effect.

Dr. Haldane had now put forward a suggestive explanation which was in some ways on the same lines as one that the writer had in mind in 1915, when he stated that "certain investigations now being carried on by Dr. H. C. Ross suggest that this action of clay in modifying the influence of silica-dust, which appears to be similar to that exerted by coal, depends on the presence of certain organic constituents in these materials."

However further work might show that certain inhibitory influences can stay the action of silica-dust in producing fibroid phthisis, he (Dr. Collis) felt at present unconvinced that the evidence before them was sufficient to establish that any other dust except that of fine silica had the power of causing fibroid phthisis. He was, of course, aware of the work to which Dr. Haldane referred that was being carried on by exposing animals to dusts of emery and carborundum. These experiments undoubtedly showed that the lungs of the animals exposed were damaged; but in actual practice there was no evidence to establish that men exposed to the inhalation of such dusts suffered from fibroid phthisis, or that the lungs of such men showed the characteristic

shadows when radiographed, and the same remark applied to men exposed to fine glass-dust. He would therefore venture to submit that the problem before them was a double one. First, how was it that silica only among the dusts was associated with a heavy mortality from fibroid phthisis? Secondly, how was it that this mortality was profoundly modified, if not entirely inhibited, when the silica was combined with certain other materials, notably those containing certain organic constituents?

Dr. H. C. Ross wrote that the experiments to which Dr. Collis had referred were preliminary ones made by him at the Lister Institute. The fact that certain forms of coal-dust and clay seemed to render silica-dust inert as regards causing miner's phthisis led to the suggestion that this neutralizing property of the coal and clay might be due to a certain chemical grouping. Recent research had produced evidence that the predisposition to cancer caused by tar, pitch, and soot was probably due to this grouping, and since there seemed to be an antagonism between the predisposing causes of cancer and tuberculosis, it was suggested that the grouping which caused pitch-cancer might be responsible for the neutralization of tuberculosis brought about by coal-dust and clays. "Blind" experiments were then made, when it was found that in the majority of instances this "auxetic" (nitrogenous) grouping was to be detected in those forms of dust which contained clay and not in those which produced miner's phthisis. The writer had already published details of this work in the Report of the Medical Officer of Health for the County of Essex (Tuberculosis, 1914). It was mentioned now because it might be possible that the "stimulation" referred to by Dr. Haldane was due to the chemical grouping with which the writer experimented.

Mr. H. W. G. Halbaum wrote that it was difficult to disagree with any part of the author's excellent paper. The theory of alloys considered as solid solutions was not new. Dr. Haldane had, however, shown that this principle of alloys as solid solutions applied not only to metals but to non-metals also. That step forward seemed most natural and logical. But it started new trains of thought: for example, it suggested the idea of saturation. If so, they must suspect that it was possible to overdo the stone-dust treatment. Or did the alloying action, as carried out in the lungs, proceed between, say, argillaceous and arenaceous shales, as well as between coal-dust and siliceous stone-dust?

A further suggestion was that if the alloying process was to be assisted as much as possible, the elements of the alloy should approach, as nearly as possible, the liquid state. In other words, they should be as finely divided as possible in order that the surfaces of contact per unit of weight should be a maximum.

The author had also spoken of the fact that the nostrils acted as a kind of filter or sieve. But was there not another factor? The inhalation was also an accelerative force which acted on the atmosphere outside, putting the air in motion and drawing the air into the lungs. Like every force, the force of inspiration would produce smaller accelerations in larger masses. Hence, it was reasonable to suppose that, in drawing an inspiration in air containing solid matter in suspension, the lighter particles would be drawn into the lungs more rapidly than the heavier particles of equal bulk. It would appear, therefore, that in air containing solid particles of different specific gravities (*cet. par.*) the nostrils had a selective capacity as well as a filtering action. If so, one must conclude that in considering the suitability of any stone-dust, not only the specific gravity of the substance in bulk, but the difference of the specific gravities of its various ingredients also, must be taken into account.

Dr. Haldane's paper went a long way towards proving that, to be at once innocuous and efficient, the stone-dust must be as finely divided as possible, and not only *distributed* by the air-current, but *selected* by the air-current. In other words, the air-current should sustain the same relationship to the mine and perform the same dual office as the nostrils sustained and performed for the individual.

Sir William Atkinson, I.S.O. wrote that it appeared from Dr. Haldane's valuable paper that the physiological action and effects of the inhalation of different sorts of dusts were not yet thoroughly understood. There was, however, so far no evidence that the use of shale-dust as applied for making coal-dust inexplosive was injurious to health. Stone-dusting had now been practised in some mines for several years, and he would suggest that a medical enquiry should be instituted as to the hygienic effect on the

men most exposed to the inhalation of stone-dust in such mines.

Dr. William Galloway wrote that the fact that the black dust actually present on the roads in mines contained a high percentage of stone-dust, was shown by Freire-Marreco's analyses of dust collected from the roads, and elsewhere, in Penygraig Colliery,* and by Prof. C. M. Thompson's analyses of dusts from Altofts Colliery,† and had been commented upon at that time, and frequently in later years, long before investigations on the subject were undertaken in the Doncaster Coal Owners' Laboratory.

Dr. Haldane's explanation of the reasons why certain dusts and mixtures of dusts were removed from the lungs by epithelial cells which wandered away with their load of dust-particles and were eliminated by the cilia or otherwise disposed of, while flint or quartzite dust remained and tended to accumulate on the spot upon which it had first settled down, was not only of surpassing interest, but seemed to point to a far-reaching conclusion which might ultimately lead to an amelioration of the lot of miners who worked in the presence of clouds of dust of the latter kind. It was to be hoped, therefore, that the experiments to which the author referred as having been begun and as having been interrupted by war-work would soon be resumed and carried on until definite and, he hoped, eminently satisfactory results had been attained.

Principal J. W. Mellor wrote that Dr. Haldane had summed up the present state of our knowledge very clearly in the paradox: quartz-dust alone is baneful; quartz-dust diluted with about two-thirds of clay is harmless. He (Dr. Mellor) knew that Dr. Haldane doubted the accuracy of this inference from the available facts, and before the war had pressed the writer very strongly to try to elucidate the mystery. Unfortunately, war-work arrested progress in that direction. It seemed extremely improbable that the mere presence of clay inhibited the pernicious action of the quartz; and the premises on which the inference was based must be revised in order to make sure that something had not been overlooked. Through ignorance, the writer was not in a position to venture an opinion on the medical evidence as to whether the diluted quartz was really harmless, or whether it was merely slower in its action. Assuming that it was quite harmless, it seemed highly probable that the free silica present in, say, the Altofts shale was not in the form in which it was assumed to occur. It would be noted that only the very finest granules could penetrate into the lungs; and that his (Dr. Mellor's) estimate of the 35% free silica was based on the clay *en masse*. Did the composition of the clay in bulk represent the composition of the very finest dust? Although elutriation fractions showed a difference in composition, it had not yet been decided whether dust of the degree of fineness which could reach the lungs contained really 35% of free silica. A negligibly small proportion of free silica might, after all, be present in the fine fraction which penetrated to the lungs. Again, one was not sure of the character of the surface of the finest grains of free silica in the Altofts shale. The surface of the fine-grain silica was sometimes found to be corroded, so that the surface appeared to be covered with a film crust of colloidal silica. Was this so with the free silica in the Altofts shale? Probably yes, but a definite answer could not at present be returned. Consequently, he might ask Dr. Haldane whether granular quartz, each grain of which was covered by a film of colloidal silica, was harmless or harmful. Many other interesting questions naturally arose, and the impression one obtained from Dr. Haldane's admirable review was that the preliminary work had opened up a promising investigation into problems of vital importance in many prime industries.

Dr. W. F. Smeeth said that the experiments appeared to show that dust composed entirely, or nearly entirely, of quartz was particularly detrimental, owing to its being absorbed by certain cells in continuously increasing amounts, thereby producing a cumulative effect of an injurious character. The most noted example of this was the dust in the Transvaal gold-mines, which contained, probably, between 90% and 95% of quartz.*

The very different behaviour of shale-dust, which was composed largely of silicates, and of coal-dust was striking and, he thought he might say, unexpected, and the mode in which such dust was removed from the lungs so as to avoid cumulative and permanent injury was extremely interesting. It was still more remarkable that dust containing only some 20% or so of silicates or

* *Proc. Roy. Soc.*, 1882, vol. xxxii., page 400.
† *Ibid.*, 1887, vol. xlii., page 174.

* This is an over-statement.—Ed. Comm.

coal—the remaining 70 to 80 being quartz—should be of a comparatively non-injurious character, and that so small a proportion of the former should be sufficient to start and maintain the scavenging action which prevented the lungs from becoming permanently overloaded with dust.

In the case of the Kolar Mines of Mysore the dust was composed partly of quartz and partly of various crystalline silicates—probably 40 or more of the latter—and, so far as was known, this dust had not proved injurious nor given rise, in any marked degree, to miners' phthisis. This case appeared to bear out Dr. Haldane's contention that the large proportion of silicate dust present was sufficient to render the quartz-dust innocuous by securing its removal from the lungs. On the other hand, the author had referred, more than once, to the injurious effects of granite-dust, and appeared to suggest that they were comparable to the effects produced by quartz-dust. Granite was, however, by no means mostly quartz, and would contain, as a rule, 50 or so of silicates. Dust from granite would contain as much silicates as the dust of the Kolar Mines, so that if it could be regarded as fairly established that granite-dust was highly injurious, while Kolar dust was innocuous, it would appear to follow that immunity was not dependent simply, or solely, on the presence of a large proportion of silicates. Similarly, the dust of the Cripple Creek Mines was stated in the paper to contain 70 to 80 of silica, by which he (Dr. Smeeth) presumed that quartz was meant, and to be without apparent injurious effect, whereas granite, containing less quartz and more silicates, was said to be very injurious.

Those were points which he merely mentioned because he thought they required some further consideration. With regard to the question of granite, the author had stated that granite-dust was very injurious, but he was not very clear whether that dust was entirely granite-dust or not. Was it from granite quarries or mines, or something else in which granite and nothing else but granite was being worked, or was it a granite combined with quartz, in which case, of course, one could get up to any amount of silica one liked in the form of quartz? But if it were granite-dust, then, as he had said, they had two very different cases of dust, both containing about 50 of silicates, the granite on the one hand and the Kolar stuff on the other, one bad and the other not bad. He thought that this required further work or explanation.

Other factors besides the character of the dust might enter into the problem—especially when comparing widely-separated localities—and it would be a difficult matter to take account of all of them. It seemed, however, as though the experimental methods described by the author should be capable of deciding definitely whether the silicates contained in the granite behaved so differently from those contained in the Kolar rock as suggested by the records of health of miners. Was it true that the silicates of the granite were so inert that they did not excite the dust-collecting cells to wander out and perform a scavenging function, while the silicates of the more basic rocks of Kolar gave rise to considerable mobility of the cells sufficient to effect the removal of the silicate dust, and the quartz associated with it? In both cases the silicates were crystalline minerals solidified from a state of fusion, and it would be interesting to know whether the clean dust (freed from quartz for the purpose of experiment) of one set of silicates really gave rise to so much more physiological action than that from the other set. If this difference was confirmed, it would probably be related to the marked difference in chemical composition of the two classes of silicates involved, and further experiment might show that the active principle was associated largely with a particular mineral or group of minerals—for example, it might show that felspar-dust was inactive compared with dust of the ferro-magnesian minerals. There might be other ingredients also. On the other hand, it might be found that the dust, in these two cases, after experiment, did not yield very different results, in which case the marked difference in the physiological action and pathological results which had been noted would have to be sought in other causes or local conditions.

The suggestion that the activity of certain forms of dust was due to its power of adsorption was extremely interesting, and this power was, no doubt, affected largely by chemical composition. It would depend also on the physical constitution of the dust-particles, and particles which were porous or heterogeneous might be expected to give better results than solid, homogeneous particles on account of the increased opportunities they would offer for surface action in

proportion to their masses. The quartz particles would be solid and free from cleavage cracks, and this, combined with the refractory chemical character, might well render them very inactive. Most silicates, and particularly the basic silicates, would be less obdurate chemically, and would tend to possess cleavages, or to occur in flattened forms giving rise to relatively greater surfaces. The dust from shale, even though largely crystalline, was likely to be extremely minute or composed of minutely complex particles which would be relatively porous or permeable by solutions or gases. Coal stood in a different category, from a chemical point of view, and its powers of adsorption, which were referred to in the paper, might be influenced by porosity and the presence of relatively volatile constituents. He would ask the author whether any experiments had been made with charcoal-dust. Charcoal-dust was extremely porous, and had great power of occlusion, and probably of adsorption, and it would be interesting to know whether, in similar circumstances, it would be more stimulating than coal-dust.

In view of the suggestion that miners and others who had to inhale dangerous forms of dust might be made to inhale a proportion of highly active dust, with a view to promoting a scavenging action, the search for a still more active dust than that produced from coal might be worth consideration.

He would like, also, to ask whether the tubercle bacilli were taken into what Dr. Haldane had called the "dust-collecting cells" in normal cases in which there might be no absorption of mineral dust. If so, would a course of dusting with a highly active form of dust—such as coal-dust or, perhaps, charcoal—tend to promote the removal of the cells containing the bacilli, and so reduce or remove the opportunity for phthisis to develop?

Mr. John Gerrard said that if anyone suffered in consequence of the use of shale-dust, surely these youths who threw on to the sides of the roads handfuls of shale-dust and took some of it into their lungs hour after hour would have been dead long ago. In Lancashire shale-dust was being distributed on the roof and sides of the roadways from the bottom of the downcast shaft to the bottom of the upcast shaft. He had been more than once through the operation, and had come out of the pit smothered with stone-dust, and had never suffered in the slightest degree from inhaling that dust.

Mr. C. C. Ellison thought it was generally agreed that the men who got most dust into their lungs were the men who were working on the screens or in connection with grinding machinery. They probably breathed an atmosphere two or three times worse than that which was breathed at the coal-face or in the workings. It had always surprised him how very few epidemics there were in the mine amongst the men or amongst the ponies. He thought they all knew what a high value the coal had from a disinfecting point of view. The question was whether the breathing of that dust did not help in many ways to kill other germs, and so make the men healthy in directions other than with regard to the lungs. Would Dr. Haldane tell them what his experience in that direction had been? Even if Dr. Haldane had not made a study of this question, he was quite sure that from his very keen observation in connection with mines he had probably something instructive to tell them from the practical observation which he had made in his travels.

Mr. Alexander Richardson said that he appreciated the privilege of being allowed to take part in their proceedings, particularly as the paper under discussion would, he understood, be read also before the South African society.

In the old days of gold-mining in the Transvaal phthisis arising from the presence of siliceous particles in mine air received little attention, partly because the true seriousness of the danger was not recognized, and partly because it was the business of no one in particular to investigate it. Public interest in the matter was aroused some thirteen years ago by the reading of a paper by Drs. Macaulay and Irvine before the local mining society, and since then the Union Government and the mining companies had been active in their endeavours to secure purer mine atmospheres. For the removal or avoidance of dust in Rand mine atmospheres the following means, amongst others, had been tried: Water-jets, sprays, and atomizers; spraying with a dilute solution of molasses; water-blasts; water-fed drills; respirators; mechanical ventilation; and single-shift working. While all these had proved beneficial in a greater or less degree, it was probable that the last two were the most promising developments at the present time. Neither

sprays nor respirators seemed quite successful in arresting the very fine impalpable particles which floated with the air-currents everywhere and reached everybody. The paper gave rise to the suggestion that workers in mines where the dust was quartzitic should now and then be employed in coal- or other mines where the dust was beneficent in its action on the lungs. By such a change of environment they would be afforded an opportunity of recuperating their health without any financial loss to themselves.

Mr. D. M. Mowat said that Dr. Smeeth had anticipated a remark which he was going to make as to the possible application of coal-dust to the prevention of phthisis. He had had a visit the previous week from a wood merchant from Inverness. It was his first visit to Coatbridge, which was rather a smoky place. He (Mr. Mowat) had said: "What do you think of our sanatorium?" His visitor looked out of the window, which was in such a position that the sanatorium looked quite black, and said: "That is not the sort of place in which we build sanatoria; we build them on the hills." He realized while Dr. Haldane was reading the paper that this practice was wrong. People were taken away to a place where there was no chance of getting a particle of dust, the healthy remedial dust which would do some good to a man's lungs. Was not that a mistake? Might it not be advantageous to have in a sanatorium some place where a man could be introduced into coal-dust of the proper amount, that dust being, as had been proved by the results of experiments on guinea-pigs, of help in getting rid of the tubercle bacilli? If the paper led to no other good than such a suggestion being put into practice and found to be serviceable, it would have served a great purpose.

The Chairman (Sir William Garforth) said that Sir Henry Hall had stated that if the roads were stone-dusted and the stone-dust became covered with coal-dust, the danger was as before; but he seemed to have forgotten that the pockets and interstices of the mine were also filled with stone-dust. It might also be pointed out that the stone-dust was so heavy that it allowed for a velocity of air far in excess of the quantity required to ventilate a coal-mine without being removed until the coal-dust had been raised from the roadway. A velocity of air of 1,000 or 1,200 feet per minute did not remove the coal dust, but when equal to 1,500 feet, that was sufficient to take away the coal-dust; but the stone-dust still remained until a velocity of 2,600 feet was reached. Members of the Miners' Federation who had visited Mwots, some time ago had been fully satisfied from the experiments shown them that all the ventilation which was required for a mine could be obtained without interfering with the coal-dust or the stone-dust.

Dr. J. S. Haldane, in reply, said that Sir Henry Cunynghame had just hit the nail on the head as to what the real function of medicine was when he said that what one could do in the way of helping the body was only to assist Nature. If a man's lungs were injured by inflammation, the doctor could do absolutely nothing by direct means to restore the structure. The structure was infinitely fine and delicate, and the doctor was not like a watchmaker, who could put in a new wheel here and a new part there. But what the doctor could do was to study how Nature mended those things and then to study, beyond that, how he could assist Nature in the process. Stone-dusting was a very good instance of the sort. He thought it was typical of what medicine could hope to do. No medical or surgical skill could by itself extract those dust-particles out of the lungs when once they were there; but one could study how Nature got rid of them, and then one could assist Nature by putting in some other dust which would help the process.

With regard to Sir Henry Hall's communication, Sir William Garforth had already discussed Sir Henry's contention to some extent, but there was one point he wished to mention. Sir Henry Hall had pointed out that when a mine had been stone-dusted a larger and dark-coloured or black dust would be found after a short while on the top of the stone-dust, which he assumed (the speaker believed quite wrongly) to be pure coal-dust. If one examined that dust, although it was dark in colour, one usually found that there was 70 or so of stone-dust in it: it was quite an unexplosive stuff; and even if it were explosive, it would not matter: if any violent shock came like blasting, it would stir up the whole lot of dust.

Sir Henry Cunynghame said they had tried that very experiment in the experimental gallery for the purpose of finding this out, as Dr. Haldane would remember.

The exact point was tried repeatedly. They had put pure coal-dust on the top of the stone-dust, and had then stirred up the two dusts together.

Dr. Haldane said that Dr. Collis's communication was very interesting. Dr. Collis had done a great deal of very valuable work on the subject. He (Dr. Haldane) thought that one of the most valuable scientific points was his investigation of miners' phthisis amongst flint-knappers, who were engaged in dressing flints. The flints were got out of the chalk by a primitive kind of mining which had come down for thousands of years, and those flints were chipped into a suitable form for flint-lock guns, or for lighting pipes, or any purpose for which flints were still used. The men who chipped these flints into proper form worked in sheds. If one went into the sheds one would not regard it as a dusty occupation at all, but there was a slight smoke always arising from each chip. He did not suppose that the amount of silica these men breathed was a tenth of what a miner breathed in the course of his ordinary work, but it was pure silica, and it was very fine.

Both Dr. Collis and Dr. Smeeth had raised a very definite question. Attention was drawn to the difference between the effects of granite-dust and those of shale-dust, and Dr. Smeeth had put it very distinctly that in granite there was more silica, but not more quartz than in shale-dust. The proportions were somewhere about the same; and yet granite-dust was dangerous; it was granite-dust which did the harm in Cornish mines. Granite was composed of crystals of quartz, of felspar, and of mica, and all those bodies were crystalline; they were not in the amorphous form. He thought the probability was that both the felspar and the mica were more or less dangerous dusts as well as the quartz. At any rate, the dust was in a solid crystalline form, and it had no property of adsorbing things into it.

Dr. Smeeth said the point was that the Kolar stuff was equally crystalline, and was quite as crystalline as granite. Of course, a great deal of shale was crystalline too. There might be a little amorphous material. There was a difference of physical character, but Kolar stuff contrasted with granite was equally crystalline—they were both crystalline rocks.

Dr. Haldane said if that were so, it presented a difficulty. The Cripple Creek stuff was amorphous looking. Were the Kolar rocks crystalline?

Dr. Smeeth said they were very largely. The difference between the Kolar silicates and those of granite was chemical rather than physical.

Dr. Haldane said so far as his experience went it seemed that the difference depended upon the physical rather than upon the chemical state, but it might be that the chemical composition was a factor that told. He thought that the only thing which could decide that was further experiments, which they intended to carry out. Almost the next thing they intended to try was ground crystalline felspar.

Mr. Mowat asked whether the distinction might not be between igneous and aqueous. Shale was aqueous and the Kolar stuff which Dr. Smeeth had spoken of was igneous.

Dr. Haldane said all he could say was that the stuff in Cripple Creek was igneous.

Dr. Smeeth said the point was that in the Kolar stuff one had the crystalline structure as in the granite, and not more in one than in the other. The only difference was the chemical composition. That was why he suggested it might well be worth while to make an experiment on silicates.

Dr. Haldane thought that it would. There was so much about the matter which was unintelligible. He had often speculated about the point that was raised so clearly and definitely by Dr. Smeeth in regard to granite. There was no doubt about granite being harmful, although it was not so harmful as pure silica. The case which Dr. Collis mentioned of the ganister-brick makers was one of great interest. Where one mixed ganister with fireclay, as Dr. Collis had found, for instance, in Stirlingshire, where a quantity of high-resistance bricks were made, there seemed to be no lung trouble at all; the addition of the fireclay to the ganister seemed to neutralize the bad effect. As Dr. Collis had mentioned, the figures were in a blue book published a year ago by Dr. Collis and another gentleman. He had not seen them when he wrote his paper, but he had seen them since, and they were very significant. With regard to the case of the potters to which Dr. Collis had also referred, the only thing which would clear the matter up was more experiments. With regard to Dr. Smeeth's very valuable contribution to the discussion,

he would like to say that he agreed entirely with his course of reasoning on the subject. Dr. Smeeth had pointed out practically what must be the direction of future research on the subject. With regard to Mr. Mowat's point as to making a sanatorium at Coatbridge, he did not know how to express an opinion on that subject; but at a previous meeting he had suggested that it would be a good thing at the meetings of the Institution to train their lungs a little bit in the way of getting rid of harmful particles by smoking. He thought that it was quite possible that the air at Coatbridge might in some way be good for phthisis. It seemed at first an absurd thing to imagine, but he did not see why it should be absurd. There was the fact, which had been a puzzle for many years, that coal-miners suffered less from phthisis than other people. Some experiments had been made on guinea-pigs which gave the result—he could not guarantee it—that guinea pigs which had inhaled coal-dust were less susceptible to infection with tubercle bacilli. The experiments were done in this way: the guinea-pigs were first exposed to coal-dust for some time, then tubercle bacilli were sprayed into the air, and the result was that the guinea-pigs which had had the coal-dust seemed to be less susceptible to the bacilli of tuberculosis than the others. Those experiments were carried out in America.

With regard to a question put by Dr. Smeeth, he would like to mention that in a paper just published by the late Major Sewell of Newcastle Medical School (*Journal of Pathology*, 1918, Vol., XXII., page 40) clear evidence was brought forward that the cells in the lungs which take up dust-particles take up also tubercle bacilli and other micro-organisms.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Electrolysis of Cyanide Solutions.—"Further investigations in the recovery of gold from cyanide solutions by electrolysis is indicated in a patent granted to U. C. Tainton and M. F. L. A. Aymard, of Johannesburg, Transvaal, South Africa. The invention comprehends passing solution under pressure through porous electrodes arranged in an apparatus similar to a filter press, anodes and cathodes alternating with distance frames. The object is to bring the solution into intimate contact with the material of the electrodes, thereby overcoming a defect in former processes. The inventors claim to be able to precipitate 99% of the gold contained in a solution of 3 dwt. per ton in a single passage of the solution through the electrode in a period of less than 5 seconds. Electrodes are in the form of filter frames, the anode being composed of sheets of peroxidized lead covered with filter cloth, and the cathode of filter cloth supported on each side by wire gauze or perforated metal plate. In operation this cathode is to be covered with comminuted conducting material, such as finely divided graphite, which is deposited out of a liquid carrying the same in suspension. When the apparatus is thus prepared for use, a gold-bearing solution is passed through it, and gold is deposited on the graphite of the cathode."—Tainton and Aymard, *Met. and Chem. Eng.*, October 1, 1917, p. 438. (J. A. W.)

Separation of Lead as Phosphate from Antimony.—"A method, which is useful for the analysis of hardened lead, depends on the quantitative precipitation of lead as phosphate from an ammoniacal solution containing a tartrate. The solution, containing about 0·5 gm. of lead nitrate, is treated with 5 gm. of tartaric acid, then made slightly ammoniacal, heated to 80° C., and treated with 100 cc. of 10% ammonium phosphate solution (sodium or potassium phosphate must not be used). The mixture is maintained at about 75° C. for 16 hours, cooled, the precipitate collected, washed with dilute ammonium nitrate solution, dried, ignited at a low temperature, and weighed. If a sufficient quantity of tartaric acid is present, antimony is not precipitated under these conditions and may be separated as sulphide from the filtrate from the lead phosphate."—G. Vortmann and A. Bader, *Z. anal. Chem.*, 1917, *56*, 577-580.—*Jour. Soc. Chem. Ind.*, April 30, 1918, p. 211A. (A. W.)

Identification of Molybdenite.—"During the course of an investigation for molybdenum, I happened to find a most accurate and rapid method of identifying its principal mineral, molybdenite. A small piece of caustic potash is melted in a fragment of a broken porcelain dish and then a little of the suspected mineral is added. Within five minutes, if the sample is molybdenite, it swells, dissolves rapidly, giving the mass an intense red yellowish colour, and not a single speck of the brilliant scaly mineral is to be seen. When cool, if a few cubic centimetres of water be added to the residue of fusion, and afterwards some drops of hydrochloric acid, the colour begins to change and in spots appear the blue, green, yellow and red.

The reaction can be explained as follows: Molybdenite (MoS_2) having two atoms of sulphur, gives up one of them to the molten potash and forms a double sulphide of red colour, just as the one created in an ammonium-sulphide solution and which is familiar to most chemists. Although the monosulphide of molybdenum has not yet been isolated, probably due to its instability, the indicated reaction tends to prove that it exists in combination with alkaline sulphides.

I utilize this same reaction for quickly getting into solution the molybdenite, in the determinations of the metal, and it constitutes a convenient and rapid method; while it takes a long time to dissolve molybdenite by means of aqua regia, nitric or hydrochloric acid, or even through the powerful oxidizing action of chlorine gas on a concentrated solution of caustic potash."—F. C. Fuchs.—*Eng. and Min. Journal*, June 1, 1918, p. 991 (H. A. W.)

A New Separation of Tin and Tungsten in Stanniferous Wolfram.—"Pulverize the mineral carefully and fuse it with anhydrous Na_2SO_4. Take up the fused mass with boiling H_2O, dilute the solution to 700-800 cc. and acidify it slightly. The brown SnS precipitate obtained entrains with it some SiO_2 and sulphides of Mn and Fe, but no H_2WO_4. To purify the precipitate dissolve it in $(NH_4)_2S_2$, re-precipitate it as SnS_2 and calcine it to SnO_2. To determine W fuse another sample with Na_2SO_4 and take up the mass directly with aqua regia causing, thereby, the precipitation of the major part of the H_2WO_4 along with SiO_2. The separation is not quaint, however, because of the presence of metatungstic acid. Treat the filtrate, which should contain Fe (the 10% usually present in the mineral is sufficient) with NH_4OH *without excess* to bring down $Fe(OH)_3$, which entrains the W acid. Wash the precipitate free from Na salts, dissolve it on the filter with 50% HCl solution, evaporate the filtrate to dryness and take up the residue with HCl. Separate SiO_2 by the ordinary methods. The H_2WO_4 retains only traces of Fe, less than 0·2 mgm. Fe_2O_3."—Travers, *Compt. rend.*, *165*, 408-10 (1917).—*Chemical Abstracts*, April 20, 1918, p. 794. (J. G.)

METALLURGY.

Metallic Coatings on Glass.—"In *Glashüte* a new application is described of the so-called Schoop process for applying metallic coatings to glass. According to this process the surface of the glass is heated until it just begins to soften and the surface is then sprayed with finely divided metallic powders. The metallic particles are thus driven into the surface of the glass and a very durable metallic coating ensues. It is stated that when the under surface of a glass flask is treated with copper or aluminium in this way the water can be raised to boiling point in three-quarters of the time that would otherwise be necessary, and, in addition, the vessel is much less liable to crack. One would imagine that this process would have useful applications for the treatment of glass reflectors for lighting purposes."—*Indian Engineering*, March 9, 1918, p. 135. (J. A. W.)

Efficiency of Zinc-Dust Precipitation.—"Among the papers offered for the St. Louis meeting of the American Institute of Mining Engineers in October is one on zinc-dust precipitation, by W. J. Sharwood, metallurgical chemist for the Homestake Mining Co. After discussing the history and principles of the process and the methods of its application, the author takes up the efficiency of precipitation.

'A precipitating efficiency of 100% assumes pure zinc, 1 atom of which should precipitate 2 atoms of silver or its equivalent in gold or copper from the double cyanide. At this rate 1 unit weight of zinc should precipitate 6·03 units of gold, 3·30 of silver, or 1·93 of copper, but in actual practice the results are much lower. Applied to commercial dust, the laboratory test usually shows an efficiency value of 30 to 60%. Some extremely fine and pure 'artificial' zinc-dusts, prepared by redistillation of spelter, have shown laboratory efficiencies of 75% or more, and pure electrolytic zinc powder is claimed to be equally good. Otherwise the efficiency is generally higher when lead is present to the extent of a per cent. or two. Distinctly coarse or granular zinc preparations generally show very low results.

'Judged by the actual precious metal precipitated, the working efficiency on a large scale may be a mere fraction of 1% in the case of low-grade gold solutions. A considerable amount of zinc is always wasted in side-reactions, such as the evolution of hydrogen, reducing dissolved oxygen, or precipitating copper and lead. With rich silver solutions the efficiency may approach 50%, especially if no attempt is made to recover the last traces of silver.

'A practical example of mixed precipitation may be taken from the records of the Drumlummon tailing plant, covering three seasons, or twenty-four months of treatment of sandy tailing by leaching, the silver being largely in excess of the gold.

Sand treated	290,000 tons	
Solution precipitated	390,000 tons.	
	Lb. Av.	
Precipitate obtained	104,000	
Zinc-dust used	113,600	
Metallic zinc-dust	102,240	
Zinc remaining in precipitate	40,300 =	39·4%
Zinc dissolved	61,940 =	60·6%
Gold in precipitate	2,380 =	0·39% effi'ncy
Silver in precipitate	16,000 =	4·75% effi'ncy
Copper in precipitate	7,800 =	3·93% effi'ncy
Total effi'ncy (Au, Ag, Cu)		9·07% effi'ncy

'Percentage efficiency is calculated by dividing the weight in pounds by the electrochemical equivalent (Zn 32·7, Au 197·2, Ag 107·88, Cu 63·5, and Pb 103·6, under these conditions) dividing the quotient by the number of equivalents of zinc used, and multiplying by 100. The metallic zinc in dust has been taken throughout at the approximate figure of 90%

'Another instance may be taken from the published results of a month's run (May, 1911) of Sand Plant No. 1 of the Homestake Mining Co., in which the silver is about 1% of the gold value. Some lead was added to the solution as nitrate and recovered in the precipitate.

'The efficiency for gold was 1·18%, for silver, 0·73%, and for copper 0·19%, in the "weak solution," making a total efficiency of 2·1%. Similarly the efficiency (Au, Ag, Cu) in the "low solution" was only 0·71%. At the same time about 1% of the zinc was consumed in precipitating lead.'

That such low efficiencies are tolerated in gold extraction is explained by the fact that when 'low solution' is going to be thrown away it is obviously worth while to extract the last 2c. worth of gold recoverable, if this can be done at the expense of 1c. for zinc, making a fair allowance for refining cost. With zinc at 14.5c. per pound, 1 oz. Troy costs 1c. If this ounce is used to precipitate 0·001 oz. of gold (2c.) from a ton of waste solution the practice is defensible."—W. J. Sharwood, *Metall. and Chem. Eng.*, October 1, 1917, p. 437. (J. A. W.)

Working Results of a Rennerfelt Electric Steel Furnace.—"In the course of the discussion of a paper on the 'Prospects of the Electric Steel Furnace in Sweden,' by Mr. Otto Frick, Mr. I. Rennerfelt and Chief Engineer H. von Eckermann, put in the following figures as actual results, with a 1¼ ton Rennerfelt furnace (arc-type), at Ljusne in Sweden, during the five days, from 21st to 25th

November, 1916. According to them, 12 charges were dealt with in the furnace in question, the average net time per charge being 6 hours 39 minutes. The average input was 1·27 metric tons, of which 19·5% consisted of common Swedish grey pig-iron, 6·5% of billet croppings, 64·5% of bar croppings, and 9·5% of scrap. The additions were in eleven of the charges, ferro-manganese and ferro-silicon, plus in five charges, small doses of aluminium, some flux being added (Kiiruna ore = 1·8% average of the charge) in every case, plus a small quantity of lime in one case. The average output (including scrap left) was 1,236 metric tons per charge; hence the loss was 2·44%. The scrap left over represented 10·12% of the weight of the ingots and direct castings produced. The consumption of electrodes was 5·1 kg. (11·22 lb.) per metric ton (2·205 lb.), and the energy consumed 1,010 kw. hours per metric ton of steel (with 0·21% carbon) produced. The work of the furnace was intermittent, hence the larger consumption of energy. With continuous working and producing steel with a carbon content of 1·20%, the chief engineer thought the average current consumption could be reduced to 800 kw. hours per ton of steel produced."—H. von Eckermann.—*Indian Engineering*, March 16, 1918, p. 149. (J. A. W.)

Life of Electric Furnace Lining.—"The Hess Steel Corporation of Baltimore, U.S.A., claims to have established a new record in its plant for the life of furnace linings, when the lining of its No. 2 furnace (a 6-ton Heroult) lasted for 116 heats, but Mr. Axel Paulsson, metallurgist to Messrs. Hamilton and Hansell, of New York, in a letter recently addressed to "The Iron Age," states that he has records of a basic-lined Rennerfelt furnace working in the United States in which as many as 160 heats of steel have been made without repairs to the silica roof or sides, and that with acid-lined furnaces more than 200 heats have been made without repairs."—Edit. *Indian Engineering*, March 30, 1918, p. 177. (J. A. W.)

Largest Electric Steel Furnace.—"The largest electric furnace in the world for making steel has now been successfully operating about one year at Pittsburgh. It was originally built to hold 20 tons at a charge, but it regularly makes 25 tons, and has produced as high as 30 tons at a time. It is the Heroult type of furnace, so called from the French designer. In the United States and Canada it has met with more success than any other form of electric steel furnace. There are now over 150 of them either operating or under contract in this country and in Canada. This particular furnace is in the Duquesne plant of the Carnegie Steel Co., and is the only one of its size now running. There are, however, three more in process of being erected at Gary, Indiana, which will be operating soon. Six heats are made every 24 hours in this furnace, and the charge is hot metal from large basic open-hearth furnaces nearby. The steel that it yields is of the highest quality, and is used principally for small gun-forgings required by the U.S. government. Two further furnaces similar to this are now operating at the plant of the Illinois Steel Co., South Chicago, Illinois, and a third is being installed. With its two 15-ton furnaces, this is the largest electric steel plant in the world."—*Mining and Scientific Press*, April 20, 1918, p. 548. (H. R. A.)

MINING.

Earth Movements.—"The movement of the ground which resulted in the fatal accident in the Great Boulder mine may have been due:—

(*a*) To regional earth movement due to geological causes, quite independent of mining operations;

(*b*) To the effect of mining operations entirely; or

(*c*) To interaction of the two foregoing causes.

(*a*) *Possible Regional Earth Movement.*

There is a good deal of reason to think that the principal and fundamental cause of the movement in this case was regional rather than purely local, that is, arising from geological forces affecting the whole district or region rather than from purely local mining operations. There was a very perceptible earth tremor felt all over the Kalgoorlie district at the time of the accident, accompanied by a loud noise much like distant thunder, rattling of windows, and shaking of loose objects, the phenomena being those quite characteristic of earthquake shocks. So far as evidence could be obtained, the shock appears to have been even more distinct towards the north end of the Boulder hill than towards the south where the Great Boulder mine is. It was strongly felt by the Warden and the Senior Inspector of Mines at their residences at the north end, and the noise and shock led many people to suppose that there had been an explosion of a magazine somewhere in the mines. It was felt at least four miles north and two miles south of the Great Boulder mine, and some considerable distance east and west as well. Unfortunately no one appears to have noticed the direction in which the shock appeared to proceed, the general impression appearing to be that the movement was mostly directly up and down. Men in the 3,000 ft. level of the Golden Horse Shoe mine felt a heavy shock, and in the Ivanhoe shaft at 3,620 ft. the men felt it as if a heavy shot had been fired in the rock below their feet. This is noteworthy as the pillar of rock which was crushed in the adjoining Great Boulder mine was at the 2,050 ft. level, or about 1,570 ft. *above* where the men stood in the Ivanhoe shaft. If the crushing of the pillar had been the cause of the shock, one would expect the latter to appear to come from overhead.

I have been informed that a distinct earth tremor was noticed at Ora Banda, almost at the time of the Boulder shock, and Mr. Lavater, of Bewick, Moreing and Co., has reported that on the same evening, about one hour later than the Boulder shock, a shock and a heavy noise as if an explosion were noticed in the Great Fingall mine at Day Dawn. There was no fall of ground visible in the Great Fingall to account for the shock and noise.

There have been several instances now recorded on the Boulder belt of heavy booming noises underground accompanying more or less sensible earth-shocks and tremors, the records extending over a period of about 10 years. Some of the shocks have been rather alarming, leading to the belief that heavy explosions must have occurred, but until the case under review there was no visible movement of ground anywhere in the mines to account for a heavy shock. In the case of one in the Lake View mine on May 30, 1917, an accident to M. Smith, has been attributed to an outburst of rock, which may have been due to an earth-tremor felt along the eastern line of lodes at

Boulder at the time, but it is not at all conclusively proved that this was the case. The fall of ground in that instance was quite a small one, and might easily have happened without any earth-tremor to cause it.

In the Great Fingall mine at Day Dawn there have been several occurrences of booming noises and shaking of the ground, which very generally have been ascribed to heavy falls of ground in the old shrinkage stopes, but so far as I can learn there has been no proof of any connection with such falls. The shocks appear to have been more distinct in the bottom of the mine, far below the old shrinkage stopes, than in the levels near these. It is not easy to understand why the shocks would be more apparent in narrow workings deep down in the solid ground far below any possible fall of ground in the old stopes than in the immediate neighbourhood of the latter. If, however, the shocks were due to true earth tremors, they would probably be felt more strongly in the solid ground than in the upper levels where a certain amount of loosening up of the country might be expected as a result of the reef having been stoped out. One of the heavier shocks at the Great Fingall mine synchronised very closely with an earth tremor which made a slight record upon the seismometer at the Perth Observatory. The shock at Boulder on August 28, 1917, was not recorded on the Perth seismometer.

During the last ten years or so there have been a good many earth tremors recorded in Western Australia, from Marble Bar down to the south coast. Subterranean noises, similar to those heard at Boulder, have been noted very distinctly at Meckering and York where there are no mining excavations. Something of the same sort has also been reported from Burbanks, near Coolgardie.

There is a good deal of reason to believe that there have been very considerable continental movements of subsidence and elevation of the whole of Western Australia within comparatively recent geological times, and it is not at all unlikely that slow movements of more or less of the area, with readjustments and transmissions of earth-pressures and stresses, are still in progress. Such would account readily for the phenomena of earth tremors and earth noises which have been experienced.

(*b*) *Mining Operations.*

It is perhaps natural, however, that people who have given no attention to the earth tremors and movements due to geological causes should be apt to under-rate their importance, and look for an explanation of such occurrences as caused the accident on August 28 to forces with which they are more familiar, and therefore are prone to ascribe them simply and solely to mining operations. They point out that 'the Golden Mile is honeycombed in all directions, and vast quantities of ground have been taken out,' and argue, quite suddenly therefrom, that there must be a good deal of movement of the country as it gradually closes in to fill up the excavated spaces.

The Great Boulder mine is very well-filled with residues from the mill, and the filling is kept as a rule well up to the faces where the men are breaking out stone from the solid parts of the reef. These solid portions, it should be remembered, also serve as pillars to support the walls. There is a good deal of difference of opinion among mining men about the relative efficiency of pillars and filling as supports to the workings and the question is to a great extent one of degree. If large and numerous pillars of untouched reef are left to support the walls it is obvious that a considerable proportion of the reef material may be chambered out with great safety, so long as the pillars left in are amply strong enough to carry all the pressure thrown upon them without bursting. But if the chambers are increased and the pillars more and more whittled away, it is equally obvious that a point will eventually be reached at which the weight of the wall rock will become too great for the pillars to withstand, and they will become cracked and crushed, and at last may give way altogether, perhaps causing a serious collapse. The bursting of pillars by crushing may frequently be more sudden and violent than the slow crushing in of the wall-rock due to the gradual compression of filling.

The usual method of working out the ore from a mine like the Great Boulder is really a combination of pillar working and filling. Suppose a new level to be opened 100 ft. below an older one; the first thing to be done is to open winzes between the levels, thus cutting up the block of reef between them into a number of large pillars separated by very narrow passages. Then as stoping proceeds these pillars are gradually cut away from the bottom upwards, and as the ore is removed filling is run in to refill the space from which ore has been excavated. Finally, the whole of the pillar of solid stone is removed and substituted by filling. As the pillars become greatly reduced in size as the stopes are extended up to near the level above them, they very generally become crushed by the wall-pressure. In the Great Boulder mine advantage is taken of this crushing, as it enables the stone in the uppermost stopes of a block of ground to be won cheaply in comparison with that which has to be blasted from the uncrushed portions. It is worth noting in this connection that while one of the theories of the accident under discussion is that it was due to the sudden crushing of a big pillar under severe pressure, with consequent noise and shock, there have been dozens of pillars in the same mine, constituting the upper portions of stoping blocks, which have crushed quietly and without noticeable shock. This would seem to imply some quite considerable difference in the mode of action of the forces causing the rupture of the pillars in the particular case under review.

For the preservation of shafts and main passage ways through mines it is usual and good mining practice to leave large pillars of solid ground in their vicinity, but elsewhere in the workings, where more or less movement of the country can do little harm, it is usually considered quite sufficient to fill the excavations with waste rock, sand, or other available filling material. In many mines the amount of unpayable lode material left untouched in the stopes serves very thoroughly for pillars.

It is contended, however, with a great deal of reason, that the leaving of pillars in mines, unless they be very large and plentiful, may often introduce a new source of danger, as the whole of the pressure acting to drive the walls of the excavations against one another tends to become concentrated in the pillars, just as the whole weight of a big bridge is concentrated on the piers and abutments supporting it. It is conceivable, there-

fore, that the pressure may become so central on some particular pillar that it becomes crushed. The experience of the crushing of pillars in coal-mines, however, in which this subject has been followed up far more fully than in metalliferous ones, is usually that the pillars crush more or less gradually and not with very sudden disruption. The recent collapse of portion of the Collie Co-operative Colliery was, however, a striking instance of a sudden yielding over a large area.

The pressure of the rock at any given point in a mine is not at all easy to determine, although the calculation of *average* pressure is quite simple. Taking the question broadly, the pressure on a horizontal surface of one square inch at a depth of, say, 1,000 ft. is the weight of a column of rock of one inch square in cross-section and 1,000 ft. in height. Taking the specific gravity of the Belt country at 2·8, the pressure would be 1,213 lb. per square inch at 1,000 ft. depth, or 1·213 lb. per square inch per foot of depth, whatever this might be.

Molesworth gives the crushing strain per square inch of Scotch basalt as 8,300 lb. of granite as 10,900 lb., and slate as 10,000 to 21,000 lb., so we may reasonably expect that strong rocks like those of the Boulder Belt country would not approach their crushing limit of strength until a depth of 7,000 ft. or more is attained. But while the average pressure may be as above shown, it by no means follows that such pressure may be found at any particular point. We are dealing with strong, solid rock, well below its limit of crushing strain, not with fluid pressures. It is a matter of common mining experience that the rock pressures on mine timbers are often very different at different points, without any very obvious assignable reason. From considerations of this sort it may be seen that the pressure on any pillar of rock left for support in a mine is not any closely calculable amount, but may be considerably above or below the average due to its depth beneath the surface. Apparently strong pillars, therefore, may be found to become crushed unexpectedly, while some which look weak may remain unbroken.

The direction and dip of joints and faults in the rock may have a great deal to do with the amount of pressure which comes upon any portion of an excavation underground, as it is along these partings in the solid rock that motion of blocks of ground may take place. It is probably for this reason that the eastern wall of the Great Boulder lode is notably more liable to falls of ground than the western one, as not only does the lamination of the schistose country dip steeply westward, but also there are a number of faults with a westerly dip, all favouring movement of the country westward under gravitational stress. The tendency to westerly movement also may very probably be greatly facilitated by the presence of the big dike of felsite or porphyry which lies on the east side of the Great Boulder mine.

The pressure of loose ground in a mine is far more formidable than that of solid rock; indeed the latter may be said to exercise no pressure on an excavation while it remains really solid, but only begins to do so when it becomes so loosened that portions of it are enabled to move under the influence of gravity. The more it is deprived of the support of surrounding country and the more it becomes free to subside, the greater the pressure it will exercise.

In the lower levels where the greater part of the lode-material has not yet been removed by stoping the mine on the whole is still very solid, there being a great deal more of the ground still left in its original state than there is of excavated ground. The pillars then greatly exceed the 'rooms' or 'stalls,' as the stopes would be called in a coal mine, in area, and little or no collapse of the walls of the excavations is possible. It is only when the stopes are well towards completion and the area of the 'rooms' exceeds that of the supporting pillars that the walls begin to have a chance to close in, and this chance is reduced to a minimum if the excavated ground has meanwhile been replaced by filling material. It is in the nature of the case that the principal work of the mines is always being done mostly in the never-opened stoping blocks, for when a block has been stoped out and filled there no longer is occasion for men to be in it. Any danger of a great collapse of the stopes must be mainly confined to those which are worked out and abandoned, and if they have been well filled there is very little likelihood of any dangerous collapse being possible.

There is a condition in the Great Boulder mine and in the adjacent Ivanhoe and Golden Horse-Shoe mines, immediately west of it, which would appear to conduce to possibility of heavy pressure in all three mines. The principal workings of these mines are on two parallel lodes, only some 200 to 250 ft. distant from one another. Both the Great Boulder lode and the Ivanhoe-Golden Horse-Shoe lode have been stoped out nearly continuously for long distances along their length and down to over 2,000 ft. in depth, and as the ore-bodies were nearly opposite to each other we now have a large flake of country, some 200 or more feet thick, standing on its edge between two large worked-out areas in the lodes. As the lodes underlay westerly this large slab of country must have a tendency to throw a considerable part of its weight upon the Great Boulder workings on its eastern side, and it seems possible that if it were once to start to move it would soon exercise a very heavy pressure. As a matter of experience, however, as already noted, the principal pressure in the wall rock in the Great Boulder mine has manifested itself from the eastern side, not the western. It would seem, therefore, that the weight of the country intervening between the two lodes must be sufficiently carried by its footing, aided by the support given to its sides by the filling and pillars in the two mines.

To speak of the Boulder Belt as 'honey-combed' with workings is to use rather exaggerated language, for the word implies excavations greatly exceeding in volume the interstitial solid ground. Notwithstanding the millions of tons of ore which have been extracted any true model of the mines would show that the mining excavations are a very small proportion of the rock in which they have been made, and that it is only in a few places where the excavations have been large and continuous that there is any possibility of any serious collapse. A collapse of the mines as a whole is a contingency quite outside the bounds of reasonable possibility. Any collapses, if such should occur, could only be local and not general throughout the belt. With the thorough system of filling which prevails on the field even local collapses of any magnitude seem to be a very remote possibility.

(c) *Earthquake Shock in Combination with Mining Operations.*

It is not at all unlikely that the breaking of the pillar of rock which caused the accident under consideration was due neither wholly to the earth movements referred to under (*a*) above nor yet entirely to mining operations as in (*b*), but may have been due to inter-action of both causes. It has been seen that the earth tremor and shock were felt over a considerable distance, and it is still a very open question whether the shock was caused by the breakage of the pillar, or whether the latter was not merely a result of the shock. According to the explanation in (*b*) above we should have to regard the breakage of the pillar as due to some concentration upon it of gravitational stresses resulting from the mining work, while, in the alternative one, the movement of the rock and consequent shock would probably have happened even if the mines had never been opened. It is quite possible, however, that both causes operated conjointly in another way, through the mining operations weakening the power of resistance of the ground to a compressive stress tending to form an anticlinal fold more or less along the line of the Boulder group of lodes. If we had an area of rock under strong compression from both sides so as to tend to push up the centre into a ridge—whether by folding or by faulting—it would undoubtedly assist an upthrust of one side of the ridge if there were numerous deep cuts into the crown of it from mining operations. These deep cuts would greatly weaken the resistance of the arch which would tend to form, and would facilitate a faulting movement, probably of the nature of an upthrust fault rather than one due to mere gravitational subsidence.

There is some evidence of the existence of a compressive stress operating on the Great Boulder lode. From about the 1,200 ft. level downwards it has been very noticeable that when the lode is first cut at each successively lower level it appears to be under strong compression, for little flakes keep bursting off from it with a sharp cracking noise, just as flakes often fly from the free side of a block of glass compressed in a vice. Pieces of rock also often fly out from the face somewhat sharply when it is struck with a pick. As the workings become extended this state of strain in the lode material gradually disappears, no doubt owing to the relief of pressure afforded by the workings, but it is just as noticeable as ever at each new level. This feature is absent or very little noticeable in most of the other lodes of the Boulder Belt, being apparently characteristic of the Great Boulder lode more particularly. A similar condition is said to exist in the lower levels of the Great Fingall mine when they are first opened. This state of compression of the Great Boulder lode would seem to indicate that for some reason or other it is under a rock pressure not noticeable in other equally deep workings on other lodes of the district, and therefore probably due to some other cause than simple gravitational pressure due to depth below surface. The Great Boulder lode is on an old line of fracture in the earth's crust, and it seems not at all unlikely that there may be a tendency for the country to be faulted along it again, relieving compression by an overthrust movement of the hanging wall side of the lode. Such a movement entering upon a resisting pillar of ground might easily cause it to snap suddenly with a great shock. The movement of the country as a whole might nevertheless be almost if not quite imperceptible, and need not necessarily show itself uniformly throughout the mine.

If this should prove to be the correct explanation of the occurrence, the shock would be due to the relief upwards of a state of compression existing deep in the country, and would probably be facilitated by the weakening of the ground caused by mining. It seems to me that this view of the cause of the shock has more to commend it as feasible than that which would refer it to the mere weight of ground due to disturbance by mining operations.

No matter which of the above three explanations (*a*), (*b*) or (c) be considered to be the most correct, the practical outcome is the same; we can do nothing better for safety and to prevent rock movement and danger therefrom than by filling the excavated stopes as thoroughly as possible. If an earthquake shock should then occur, bringing into play enormous forces of unknown and unforeseeable magnitude which we cannot lay plans to provide against, we know that the utmost possible has been done, and that the filling will probably prevent the walls from coming together completely, giving the best chance of protection to men underground of anything which can be done. So, too, if the ground tends to collapse merely from its own weight, nothing we can do is safer than to have it supported to the utmost available by good filling. The filling is better than pillars of rock, for it constitutes a more or less compressible pillar almost continuously throughout the worked out areas in the lode, while if pillars should burst through pressure the empty spaces between them are very liable to be completely filled by collapse of the walls." — STATE MINING ENGINEER, W. AUSTRALIA.—*Journal of Chamber of Mines of W. Australia*, May 31, 1918, p. 119. (H. A. W.)

MISCELLANEOUS.

FERTILIZERS IN SOUTH AFRICA.—"The growing dearth of fertilizers is causing much anxiety, and the Scientific and Technical Committee is making strenuous efforts to replace those previously imported by locally manufactured substitutes. At the present time importation has practically ceased, and there is no available supply to make good the deficiency. Phosphates are needed for maize and nearly all other crops, whilst nitrogen is essential for wheat and sugar. Attempts are being made to utilise the large deposits of iron-alumina phosphates known to exist in South Africa, and the technical aspect of this known problem is attracting much attention. About 200 tons per month of ammonium sulphate is being produced as a by-product by the Natal Ammonium Company, but it is practically all exported to Mauritius for the sugar plantations; very little is used in the Union, although export is only allowed after local demands have been satisfied. There is great need for educational propaganda. The principles of crop rotation, green-manuring, and fallowing are but little understood, soil analyses are but very seldom made, and in many instances acid fertilizers like superphosphates have been applied to acid soils."—*S. Afr. J. Ind.*, Jan., 1918.—*Jour. Soc. Chem. Ind.*, March 30, 1918, p. 113R. (A. W.)

METHODS OF GAS WARFARE.—"An interesting description, by a member of the British Military Mission, of the development of the German gas

offensive from the first gas cloud of Cl to the use of $COCl_2$, various tear- and sneeze-producing gases, poison gases and the latest accomplishments with gas shells; also of the masks, respirators, etc., developed as a protection against the various gases. The following lists the compounds used by the Germans: Clouds: Cl, $COCl_2$; hand grenades: bromo- and chloro-acetone, Br, chloro-sulphonic acid, dimethyl sulphate, methylchlorosulphonate, SO_3; shells: allyl isothiocyanate (allyl mustard oil), benzyl bromide, brominated methyl ethyl ketone (bromo ketone), dibromoketone, mono- and tri-chloromethyl chloroformate (palite and superpalite, resp.), nitrochloromethane (chloropicrin or nitrochloroform), dichlorodiethyl sulphide (mustard gas), diphenylchloroarsine (sneezing gas), dichloromethyl ether, phenylcarbylamine chloride, $COCl_2$, SO_3, xylyl bromide (toyl bromide). For protection against Cl cotton pads soaked in solution of Na_2CO_3 and $Na_2S_2O_3$ were used; when the Germans started to use $COCl_2$ a helmet saturated with PhONa was developed, but the substance now used extensively by all is $(CH_2)_6N_4$, which, used in conjunction with PhONa, will protect against $COCl_2$ at a concentration of 1 :1000 for a considerable period. The box type of respirator was developed as the use of gas shells became extensive, and employs active absorbent charcoal and alkaline permanganate, which will protect against nearly everything used, even up to concentrations of 10% for short periods. The German apparatus has the chemical in three layers: an inside layer of pumice with $(CH_2)_6N_4$, a middle layer of charcoal (sometimes blood charcoal) and an outside layer of baked earth soaked in K_2CO_3 solution and coated with fine powdered charcoal. It is not equal in efficiency to the American or British respirator, breaking down at a concentration of 0·3% of certain substances."—S. J. M. Auld, *J. Wash. Acad. Sci.*, *8*, 45-58 (1918); *J. Ind. Eng. Chem.*, *10*, 297-301 (1918).—*Chemical Abstracts*, May 20, 1918, p. 1017. (J. G.)

Metric System.—"I am in receipt of an official copy of the final report of the (British) Committee on Commercial and Industrial Policy After the War. From this voluminous report, I give below a few extracts from Chapter X., on weights and measures:

'Having given full consideration to the subject, we are unable to recommend the compulsory adoption of the metric system in this country. In our opinion, it is absolutely certain that the anticipated uniformity could not be obtained for a long period, if ever. There is, further, the serious objection that if we induced certain countries to change over to the metric system we should be surrendering to Germany the advantages which our manufacturers now enjoy over hers, both in their markets and our own. We are informed that even in France, which has made the metric system nominally compulsory for more than half a century, the '*pouce*' (or inch) is used in textile manufacture and numenous local measures still survive.

In referring to these considerations, we have to point out that there is no unanimity even as to the theoretical merits of the metric system as compared with our own. The practical argument that its adoption is desirable in order to secure uniformity in the markets of the world has been shown to be unfounded. We are not satisfied by any evidence which has been brought before us that trade has actually been lost to this country owing to the fact that the use of the metric system is not compulsory. But to attempt to make the use of the system universal and obligatory in this country would cause great loss and confusion at a particularly inopportune moment for the sake of distant and doubtful advantages. We are convinced that, so far from assisting in the re-establishment of British trade after the war, such a measure would seriously hamper it.

As regards the educational advantages claimed for the change, we have been referred to a statement quoted by the Select Committee of 1895 that no less than one year's school time would be saved if the metric system were taught in the place of that now in use. The information which we have received does not support that statement, and, even if it were well founded, it must be remembered that for at least a generation children would have to learn both the new and the old measures and how to convert from one to the other.

It is often popularly supposed that the introduction of the metric system would render possible the immediate sweeping away of many complicated and varying weights and measures. As we have already indicated, this belief is, in our opinion, wholly fallacious. We are not convinced that the metric system is, upon the whole, even theoretically superior to the British system, and we are satisfied that the practical objections to the proposed change are such as decisively to outweigh any advantages which are claimed for it.'

It is to be noted, moreover, that while in an appendix to the report several members of the committee, which consists of 19 members, hl-reservations regarding certain items, there is no reservation regarding the chapter on weights and measures. In other words, the report, so far as this chapter is concerned, is unanimous."—F. A. Halsey.—*Engineering and Mining Journal*, June 1, 1918, p. 1013. (H. A. W.)

Abstracts of Patent Applications.

792.17. Nitrogen Products Company. Improved process for forming cyanogen compounds. 11.12.17.

This application is for a process and apparatus patent for producing cyanide compounds.

24.18. Leo. Lee Mushett. Improvements in combined tube-mills and ball-mills. 17.1.18.

This apolication relates to an improvement to tube-mills by dividing transversely any standard tube-mill into two compartments; using one compartment as a ball-mill and the other as a pebble-mill.

An essential feature is a spiral feed lifting device situated in a partition between the two compartments for the purpose of accelerating the passage of the pulp.

In the construction as shown in the drawings accompanying the specification, the ball chamber receives the coarse ore, which is then passed into the pebble-chamber by the spiral device referred to above.

Claim 4 is for a tube-mill constructed and operating substantially as described and shown in the drawings accompanying the specification.

104.18. W. E. Nettle (1), Paul Selby (2), Jas. Blythe (3), J. H. Holman (4). Improvements applicable to reciprocating rock-drills, for supplying water to the bore holes during drilling. 15.2.18.

This application refers to a reciprocating rock-drill having a passage formed through the reciprocating parts, a fluid-holding vessel or container attached to the rear end of the drill, and a tube which is attached to the reciprocating parts, and is in communication with the said vessel or container and with the passage through the reciprocating parts, substantially as described.

Other claims refer to means for carrying out the idea embodied in the main claim.

The distinctive feature of this application is that the tube carrying the water through the whole piston to the drill bit is attached to the reciprocating part instead of the usual practice of having the tube fixed to the stationary part of the drilling machine.

111.18. A. A. Lockwood. Improvements in treating ores. 22.2.18.

This application describes and claims a process for the extraction and precipitation of gold and silver from a cyanide solution or pulp without filtration. It is carried out by agitating the pulped ore in a cyaniding vessel, leading the pulp from the vessel to one end of a precipitating vessel which contains a series of longitudinally arranged depending electrodes, passing a current through the pulp, maintaining the pulp in suspension in the precipitating vessel by a jet of air, removing the pulp from the other end of the vessel, leading it back to the cyaniding vessel and repeating the cycle of operations. Iron silicide anodes and lead-coated iron cathodes are employed.

146.18. W. W. Webster (1), E. Edser (2), L. A. Wood (3). Improvements in or relating to the concentration of tin wolfram ores. 4.3.18.

This is a specification concerning improvements in the concentration of tin and wolfram ores. The application relates to improvements in the concentration of tin and wolfram ores, and it refers more particularly to the concentration of such ores wherein the metal is present as an oxide. The applicants point out that this is usually done by mechanical methods such as by tables, jigs, slimers, etc. They also state that with these methods a very large amount of metal is lost, in some instances amounting to as much as 40% to 50% of the metal contents of the ore.

199.18. J. H. Veasey. Improvements in connection with rock-drills for allaying dust. 28.3.18.

The claims for this application refer to water feed of hammer drills. The first three claims are as follows :—

(1) In the operation of a rock drill in which fluid is discharged into the hole through a hollow tool, forcing water under pressure through the tool to the exclusion of air.

(2) In a rock drill in which an axial tube passes water into a hollow tool, preventing the entrance of air from the drill into the tool bore.

(3) In a rock drill in which an axial tube passes water into a hollow tool, a packing between the tube and the bore of the tool and means to prevent the accumulation of air pressure in the chuck cavity.

Other claims have reference to the first three claims detailing means whereby the provisions of these could be carried out.

235.18. W. Ross. Improvements in grizzlies for ore separation. 16.4.18.

This application relates to improvements in revolving or travelling type of screen by providing a device which allows every alternate bar to swing downward, and so automatically increases the spacing of the bars on the return or underside of the screen, and avoids choking.

284.18. R. P. Park. Improvements in and connected with machines for reducing ore. 10.5.18.

This application refers to improvements in and connected with machines for reducing ore, the primary object being to provide means whereby a maximum amount of ore may be pulverised to any desired degree in a minimum of time.

The invention mainly applies to a revolving ring or table, which carries the ore beneath a succession of crushing or grinding rollers which are adapted to gradually reduce the ore to any desired state of sub-division. This gradual reduction is due to the arrangement of the rollers in stepped relationship to the table.

304.18. M. J. M. Mallac. A new motor fuel known as "Callac." 1.6.18.

The application is for a new motor fuel consisting as is claimed of the "chemical" mixture of (1) hydrocarbide ($C_{10}H_{12}$), such as for instance, oil of turpentine or any other oil belonging to the pinus sylvestris species. (2) Petroleum ether, petrol, petroleum spirit or motor spirit or ether. (3) Naphthalene. (4) Ethyl alcohol whether pure, methylated, denatured, or otherwise, and no matter from what source derived. The alcohol to be of not less than 90% of purity.

310.18. A. F. Crosse. Improvements in obtaining phosphates from certain phosphatic rocks. 8.6.18.

The process consists principally in treating impure phosphate of alumina and phosphate of iron rock with carbonate of soda and calcining asme. Further treating it with caustic lime, forming thus an insoluble phosphate of lime, with caustic soda in solution the last being regenerated afterwards with carbon dioxide.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Fraser, A., *l/o* Brakpan; c/o Modder B. Gold Mines, Ltd., P.O. Modderbee.

Fry, A. T., *l/o* Broken Hill; c/o Mt. Lyell M. and R. Co., Ltd., Queenstown, Tasmania.

Leonard, D. T., *l/o* Selukwe; Sali Mine, P.O. Shabanie, S. Rhodesia.

Neill, J. M., *l/o* Geduld; Post Office, Selukwe, Rhodesia.

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Vol. XIX NOVEMBER 1918. No. 5.

Proceedings
AT
Ordinary General Meeting, November 16, 1918.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 16th November, 1918, Mr. H. S. Meyer (President) in the chair. There were also present:—

16 Members.—Messrs. H. A. White, C. H. Greathead, J. R. Thurlow, F. Wartenweiler, F. W. Watson, W. R. Dowling (Members of Council), W. Beaver, W. Bleloch, A. King, C. A. Meiklejohn, H. H. Morrell, P. T. Morrisby, S. Newton, J. Thorlund, and J. T. Triggs.

6 Associates.—Messrs. J. Davidson, C. L. Dewar, C. H. Olsson, J. de Villiers, A. Willcox, and J. A. Woodburn.

6 Visitors, and Fred Rowland, Secretary.

MINUTES.

The President: As you are aware, we were compelled to abandon the meeting that was to be held a month ago, on account of the wish of the Medical Officer of Health and the Authorities, who considered the influenza epidemic made it unsuitable for meetings of this description. The meeting was held over therefore until to-day.

We now have to confirm the Minutes of the September meeting.

The Minutes of the Ordinary General Meeting held on the 21st September, 1918, as recorded in the September *Journal*, were confirmed.

THE ARMISTICE.

The President: Before we proceed with the ordinary formal business of this meeting, I am sure you wish me to say a few words to express our heartfelt gratitude that we can meet again under conditions which a month ago could never have been foreseen, or for which we could have barely hoped. There is so much said at the moment and so many eloquent speeches made to celebrate this occasion that I feel sure that in an impromptu fashion I cannot do the matter justice. At the same time, I am sure you would wish me, on behalf of the members of this Society, to express our unbounded admiration for all those who have taken a prominent and leading part in bringing matters to this happy conclusion.

It is invidious for me to go into details or mention anyone in particular. I presume you will ask me to include the army, the navy, the medical service, the nurses, those behind the lines, and every man Jack who has contributed anything towards this result. As far as our own Society is concerned, many of us are too old, many of us are too maimed, many of us so-called indispensables,—we must derive what little consolation we can from that title. Added to these are those of our members who have been fortunate enough to be able to take part in the war—and these together with above mentioned who have helped to keep the industry going, form the sum total of the little that we have been able to do. I am not in possession to-day of the names of those members of our Society who have lost their lives or who have been disabled during this war, but, as it touches us nearest, I should like you to rise in their honour, and to think of those we have been unlucky enough to lose.

All present rose to their feet.

ELECTION OF NEW MEMBERS.

Messrs. H. A. White and J. R. Thurlow were appointed scrutineers. After their scrutiny of the ballot papers the following new members were declared unanimously elected:—

BEARPARK, ARTHUR FREDERICK, P.O. Box 497, Durban. Consulting Chemist (*from January 1st, 1919*).

BRANDFORD, THOMAS, Central Mining and Investment Corporation, Ltd., P.O. Box 1169, Johannesburg. Mining Engineer.

HINGLE, LEWIS DENYER, Rand Mines, Ltd., P.O. Box 1169, Johannesburg. Mining Engineer.

MELLOR, EDWARD THOMAS, D.Sc.(Lond.), F.G.S., M.I.M.M., Central Mining and Investment Corporation, Ltd., P.O. Box 1169, Johannesburg. Consulting Geologist.

The Secretary: Since the last meeting the Council has admitted the following gentleman as an Associate:—

BOYD, JAMES ALFRED, 257, Bertha Street Kenilworth, Johannesburg. Laboratory Assistant.

GENERAL BUSINESS.

THE FURNACE AS AN ADJUNCT TO THE SMITHY ON A GOLD MINE.

The President: In this connection, a report has been issued recently, giving a great deal of data about the local utilization of scrap material and such like by means of furnaces, and this will be abstracted for the next *Journal*. So some more information on this subject will be forthcoming.

CHRISTMAS VACATION.

The Secretary: The next meeting of the Society will be held in February, the usual vacation taking place in December and January. The *Journal* will be issued as usual every month. We have a fresh paper for the December *Journal* and, I believe, for the January *Journal*, both of which will come up for discussion at the meeting in February. Meantime, the Editorial Committee will be glad to have the remarks of members on any papers under discussion for publication in the *Journal* as early as possible.

VISIT TO NEW MODDERFONTEIN.

The President: Mr. Rowland has omitted to mention that there is a possibility of our being able to arrange a visit to the New Modderfontein new plant; the date, as provisionally arranged, will be about the 18th January, 1919. The idea is to make it a joint visit with the other technical Societies here, as there are matters which would interest both the Electrical and Mechanical and, in fact, every kind of Engineer who is engaged on these fields.

Therefore, the idea is to make this a joint visit. I might say, at the same time, that I hope an invitation of this description will meet with a little bit better response from the members than others we have embarked upon.

As it is so long since we have had an opportunity of discussing general matters, I should be glad to give anybody the opportunity this evening to ventilate under the heading of "General Business," anything that may be of interest or value in furthering the Society's interests.

The President: Mr. Macer is suffering from influenza at the moment, but the Secretary will read his paper.

NOTES ON THE FOOTWALL BEDS OF THE FAR EAST RAND REEF.

By L. W. MACER (Associate).

It is generally assumed that the stratigraphy of the Far East Rand is simplified by the existence of the "slate" footwall, correlatable with the "black bar" of the Central Rand, and which is so easily recognised that it constitutes a reliable indicator for the payable reef of this area. The object of these notes is to point out that this deposit is of a variable nature, both petrologically and in its mode of occurrence, and is not so readily distinguished as is generally supposed.

The footwall beds.—The variations of the black bar as existing on the Central and East Rand, namely, from a black satiny slate to a banded pyritic quartzite and coarse conglomerate, also all exist in the Brakpan Mines. The change from fine to coarser sedimentation, in most cases, takes place gradually, the shale becoming more quartzitic and finally containing pebbles. Occasionally the coarseness of the constituents increases rapidly and irregularly, and the reef is found lying upon a conglomerate with very little quartzitic matrix. This condition is shown in Fig. 1, which represents an exposure along the 15a W Drive at Brakpan Mines. Here the footwall changed from normal slate to quartzite, in which two steeply inclined beds of conglomerate were encountered. After passing the small reversed fault, reef was exposed in the roof of the drive lying on a few inches of shale. This shale widened and passed into the foot, having the appearance of having been intruded from below. Further west the footwall became more shaly and finally changed into the normal "footwall slate."

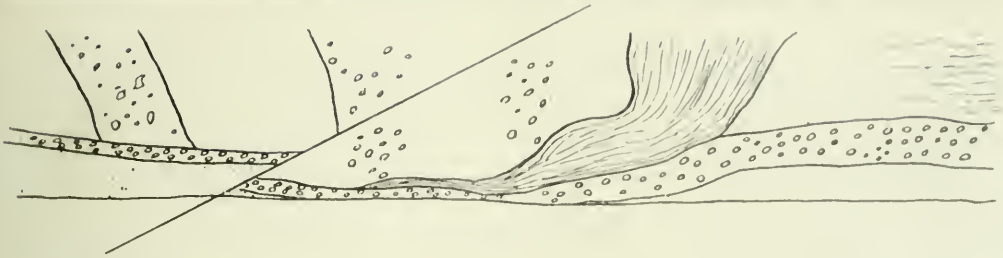

Fig. 1

In this instance the reef had a well defined footwall parting, but in many cases in this mine it is rather difficult to see where the pay reef ends and the footwall bastard begins.

Under conditions as indicated above, it is perhaps superfluous to point out the possibility of error occurring in the interpretation of the data available from a borehole core or the intersection of reef in a shaft. This possibility led the writer to study the footwall bastard rather extensively, and to place on record some of the distinguishing characteristics of the deposit.

In the footwall conglomerate the quartz pebbles have a rather more milky appearance than have those of the Main Reef Leader, although clear vein quartz pebbles also occur. There is a considerable variation in size and shape of the pebbles of bastard reef. Black quartzite (chert) is not so frequently found, but pebbles of grey, very fine quartzite are very numerous. The main distinguishing feature is the occurrence of pieces of yellowish grey or greenish rock, which, after a few weeks' exposure to the mine air, turn brown. Under the microscope this rock consists of a micro-crystalline ground mass of quartz with a few opaque, eroded crystals, and is probably an altered quartz porphyry. In the hand specimen these fragments of rock appear to

Scale 1/5.

BASTARD REEF SHOWING QUARTZ PORPHYRY FRAGMENTS A.A. INDENTED BY HARDER SURROUNDING PEBBLES.

have been originally softer than the other constituents of the conglomerate, and to have been squeezed into very irregular shapes and indented by the quartz pebbles. This irregularity in shape of the fragments gives the weathered rock the general appearance, at a distance, of having been splashed with brown mud. The matrix is quartzitic and pyrite is scarcely noticeable. The gold value is practically nothing.

Sedimentary Dikes.—Sedimentary matter having the appearance of having been intruded, is mentioned by Geikie* and other geologists, but does not appear to have been previously observed on the East Rand. The writer's attention was first drawn to these dikes by the difficulty which was being experienced in distinguishing between hand specimens of "dike" and "footwall." Thin sections of the so-called dike matter had almost the same microscopic appearance as the normal "black bar," and on examining the dikes *in situ*, they were found to be intrusions of footwall.

It appears probable that the more argillaceous portions of the footwall beds have retained their plasticity long after the superincumbent quartzose beds were laid down and partially consolidated, and that as the latter became heavier the clayey deposits were forced up along lines of least resistance.

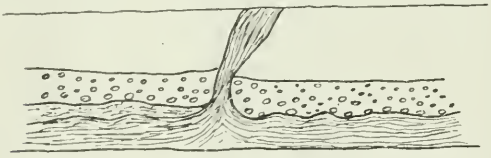

Fig. 3.

Fig. 3 shows a typical occurrence (main inclined shaft, Brakpan Mines) which has been mistaken for an igneous dike. The flow structure, as indicated in the figure, is very obvious.

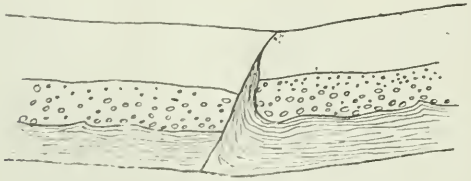

Fig. 2.

The occurrence illustrated in Fig. 2 is interesting as an instance of the way in which these intrusions may lead to error in development. In this case the round broke to the line of the fault, showing a face of slate nearly to the roof of the drive. The indication was that an up-throw had been encountered. The next round showed the reef in the normal position. Had this intrusion been of greater extent it is probable that the raise would have been steepened to look for the reef, which would then have been passed over.

The intrusions do not extend a great distance laterally, as is shown in Fig. 4. In

Fig. 4.

this case five cross-cuts were driven in faulted ground at varying intervals over a total distance of 500 feet. Three of these cross-cuts are illustrated, the ones at either end being omitted, as they only disclosed simple faults. At first sight it appears that these intrusions occur in fault planes, but after the examination of a number of cases the writer is of opinion that the intrusions occurred first, and by forming lines of weakness they led to the formation of faults.

Conclusion.—It is obvious that the intrusion of masses of sediment, indistinguishable petrologically from the normal footwall, *may* lead to futile excursions into the hanging wall by raising or cross-cutting, and that the geology of the "black bar" is therefore worthy of the attention of those engaged in development work. To those engaged in the exploitation of new areas it is of even more importance, as it is possible for a drill hole or even a shaft to intersect an area of irregular sedimentation, complicated with faulting, and to pass the Main Reef Leader unnoticed. Such a possibility is illustrated in Fig. 5. All four of the difficulties here illustrated occur in the Brakpan Mines, namely, an intrusion of footwall with a fault, the Main Reef Leader consisting of a single layer of pebbles and a further leader lying on slate at a depth below the Main Reef Leader of about 160 ft. Although not occurring in the same section, these phenomena were encountered within a radius of 200 ft. It is conceivable that a shaft put down as shown in Fig. 5 might have resulted in development being commenced upon a wrong horizon.

* Text book of Geology, p. 665.

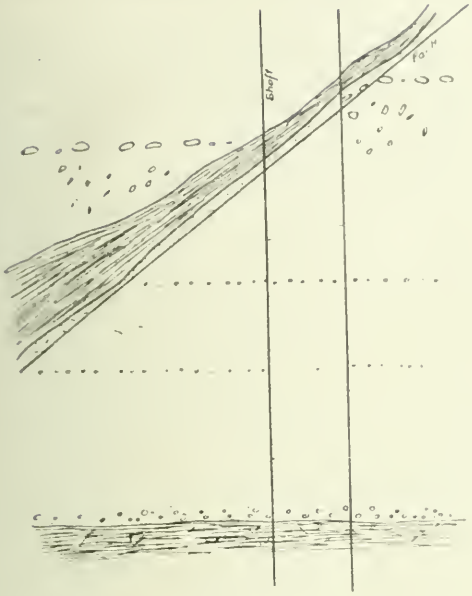

Fig. 5.

It was not the intention of the writer in these notes to venture outside the field of practical mining geology, but with the evidence exposed in the workings at Brakpan, bearing as it does upon the origin of this formation, it is difficult to leave the subject without theorising upon the conditions prevailing when the footwall beds were deposited. We have within a comparatively small area evidence of extensive mud flats alternating with sand banks and pebbly banks, and one is impressed with the amount of incontrovertible evidence in support of Dr. Mellor's estuarian theory.

The writer hopes that not only will these notes be of some little value to engineers engaged in the exploitation of the newer areas of the Far East Rand, but will also lead to further information as to these footwall beds being placed on record by those engaged in development work on mines in this district.

The President: I should like to move a a vote of thanks to Mr Macer for his very interesting notes. They are of a highly technical character, in the sense that they represent the observation of a man who has to deal with these matters underground and, therefore, I do not suppose there is any particular occasion for the subject to be generally discussed this evening.

To those who are interested in this subject, it gives an opportunity to look a little closer into the mines with which they are connected and to see whether the points that he has placed before you this evening can be adapted to practical utility in their own particular sphere. There is nothing particularly controversial or theoretical, it being a plain, straightforward relation of facts as they have been observed by the writer.

The only reference I have seen for some considerable time to the subject which Mr Macer has chosen is in Dr. Mellor's paper on the Upper Witwatersrand System, read before the Geological Society, on the 11th June, 1915, where he refers to the existence of conglomerates below the horizon of the Main Reef Leader on the Far Eastern Rand. Here he illustrates this point by a section in the Brakpan Mines; and I am not sure whether it is not a very similar one to the one, or to one of those, brought forward by Mr. Macer this evening. And he states that boreholes in the vicinity of this section show that the body of quartzite, shale and conglomerate which lies below the reef horizon rapidly thickens to 200 ft. at a distance of 400 ft. from the point where it is first observable. The feature to which he calls particular attention is the peculiarly undulating nature of the bedding and the association of the coarser deposits with slatey beds, the variable distance below the foot-wall of the "Leader" at which conglomerates occur, and their intermittent character. He gives the opinion that these scattered bodies of variable conglomerates are to be regarded as belonging to the same group as the variable sediments found below the Main Reef Leader at intervals from the Primrose and Glencairn to the East Rand Proprietary Mines.

Possibly that portion of Dr. Mellor's views which are not referred to in Mr. Macer's paper is the one that may give rise to the most interesting portion of any discussion that may come from this paper.

Mr. W. Bleloch (*Member*): The paper is extremely interesting to me as a student of these beds on the Far East Rand. There are one or two points in the paper which I think call for special comment. One is the photograph which shows the occurrence of quartz-porphyry pebbles—in these banket beds lying between the Van Ryn Reef and the footwall shales at some places in the Brakpan Mines. I may say there are similar occurrences in other mines on the Far East Rand: that is, the occurrence of bankets below the Van Ryn Reef proper. Similar pebbles are found in the Van Ryn

Reef itself and so far as I know, these quartz-porphyry pebbles are peculiar to the Van Ryn bankets. I do not know of such pebbles occurring in what I call the Central Rand Main Reef Series. It would be rather interesting if members who are engaged in Central Rand Mines would take note of the occurrence of these quartz-porphyry pebbles mentioned by Mr. Macer in these beds in Brakpan which I believe are peculiar to the Van Ryn Reef Series of the Far East Rand and find out whether or not they occur in the Main Reef Series. As is known, one man cannot see everything, and, if all members looked for evidence on such points, I think we would gain a great deal of valuable knowledge.

The next point which the author brings out fully in the illustrations is the occurrence of the intruding material he describes apparently from the footwall shales. It appears that the mud which formed the footwall shales of the Van Ryn while it was still more or less plastic was in places forced through and between the beds in the same way as the material of igneous dikes has been forced through and between the beds. These are extremely interesting illustrations, and for those members who live in Johannesburg I may say that I happen to know of a place close at hand, where a similar occurrence can be seen, that is on Langerman's Kop. Looking from Bezuidenhout Valley, one will see the footwall shales of the Kop running along below the quartzite banket beds and at a point about the middle of the Kop, these shales are to be seen intruding into the quartzites right to the top of the Kop, giving all the appearance of an intrusive dike. These intruding shales have been examined microscopically by, I think, Dr. Corstorphine and others, and they have been definitely determined to be of sedimentary origin.

The conclusions to which the author comes regarding Brakpan, I think, are on the whole warrantable; but I would suggest another possible explanation, and that is that we may have to do with what one might call interformational unconformity; that a certain amount of contemporaneous erosion has taken place between the completion of the deposition of the Van Ryn muds—footwall shales of the Van Ryn Reef—and the deposition of the Van Ryn Reef itself.

There, in the area at Brakpan which I have been to examine, more especially with regard to one of these occurrences, what is known as the Van Ryn Reef is found to continue right across the irregular bodies of reefs and quartzite, which occur there below it, until some distance on, the reef is found again to be lying in on its footwall shale. That is to say: in this area where these abnormal beds occur in between the Van Ryn Reef and the footwall shale the reef itself keeps on without displacement for several hundreds of feet, and after passing over that area the reef again rests on the normal footwall shales. It looks as if there had been erosion of the footwall shales at this place forming a sort of deep gulley perhaps a couple of hundred feet deep and several hundreds of feet wide, and that this gulley had been filled up with other material and the whole levelled up again before the deposition of the Van Ryn Reef.

I may say, there are other occurrences, especially further afield, down towards the Heidelberg District, which give one the impression that there was an abrupt marked change, between the conditions which prevailed when the footwall shales were laid down and the conditions which prevailed immediately after when the Van Ryn Reef itself was laid down. These shales thin out very remarkably; they sometimes get down to 30 ft. or 40 ft. thick. The normal thickness on the Far East Rand is 400 ft. or 500 ft. The Van Ryn Reef itself seems to maintain its character, and I would even say that it is distinguishable not only from these beds described by the author, in its matrix, pebbles, gold contents, and other points, but is even more distinguishable from the beds of the Central Rand Main Reef areas or any other of the banket beds of these fields.

I do not think I need say anything more except to express the pleasure I have had in reading the author's paper, and to thank him for the information he has given us.

FURTHER NOTES ON SANDFILLING OF MINES.

By C. H. Greathead (Member of Council.)

(Printed in Journal, April, 1918.)

The President: It is very regrettable in a way that there has been such a scanty contribution to this discussion. The author's paper was a very interesting account of a definite process that he has been successful in applying to a particular problem on the Simmer & Jack Mine; and

apparently everybody has taken it in that sense. They are therefore not prepared to come forward with processes on other mines; but the author explicitly calls his paper "Further Notes on Sandfilling of Mines," and, as there are many mines that are sandfilling, the only thing I can propose is that others will come forward with "Still Further Notes on Sandfilling of Mines," as they apply to their own particular problems.

CEMENTATION PROCESS APPLIED TO MINING (FRANÇOIS SYSTEM).

By A. H. Krynauw (Member).

(Printed in Journal, May, 1918.)

The President: This paper was one in which the author outlined the principles of the system with descriptions of particular application to one or two problems which were engaging the minds of engineers here at the moment. There, again, there was very little opportunity for criticism, because so few here had sufficient experience of the process. We can only hope that when the author replies to the discussion—the very little discussion which has so far not been forthcoming—he will supplement his original paper by some information as to the success or otherwise of his practical applications, so far as they have been proved to-day.

THE ESTIMATION OF OXYGEN IN WORKING CYANIDE SOLUTIONS.

By H. A. White (Vice-President)

(Printed in Journal, June, 1918.)

DISCUSSION.

Mr. F. Wartenweiler *(Member of Council):* In our experience with Mr. White's method since its publication we have encountered several difficulties, and ask his indulgence in bringing them to notice; perhaps he can explain them or suggest a remedy.

We find that the dye standard becomes definitely lighter in shade in a month's time. It may be necessary to make fresh standards at frequent periods. We have made no effort to keep these standards away from other than direct sunlight. With some solution effluent from sand treatment, the tint formed is violet, and under this condition colorimetric estimation with the standards made is not possible. I would like to ask Mr. White if he has checked his colorimetric determinations by any of the older and slower methods he refers to.

Allowing for the difficulties mentioned, and which may be provided for or overcome, Mr. White's colorimetric method should appeal to the cyanide plant operator as a rapid means of obtaining comparative information regarding the oxygen content of solutions. After the standards of colour have been made up by an analyst, the actual determination may be carried out in a few minutes by the plant foreman or the shiftsmen. This rapidity of estimation has been desired for a long time, and we are indebted to Mr. White for his research.

It may be of interest to record a few oxygen determinations carried out at different times by this new method, on a Central Rand plant, for comparison with Mr. White's data, which is, presumably, on a plant on the East Rand.

Strong Solution Precipitation Box
Barometer, 620 m.m. Temp. 20° C.

Solution.	Mgs. O per litre.	Gold dwt. per ton	Percentage Gold precipitated
Entering 1st compartment ...	6·5	5·33	—
Leaving 1st compartment ...	0·5	0·47	91·1
Leaving 2nd compartment ...	trace	0·09	80·8
Precipit. Sol. in sump ...	6·0	—	—

It will be noted that the gold precipitates rapidly with the reduction of the oxygen, and a high percentage of the precipitation is reached simultaneously with the exhaustion of the oxygen content.

Miscellaneous Solutions.
Barometer 620 m.m. Temp. 20° C.

Solution.	Mgs. O per litre.
Strong Sand solution in steady head before precipitation	6·0
Weak Sand solution in steady head before precipitation	6·0
Slime solution in steady head before precipitation	6·0
Strong sand solution in sump after precipitation	5·5
Weak sand solution in sump after precipitation	6·0

The oxygen content shown above is not far from saturation point; 7·2 mgs. per litre being the maximum by Sutton's table.

SOLUTIONS IN SLIME SOLUTION PRECIPITATION BOX.

Temp. 21° C. KCN 0·005
Barometer, 620 m.m. CaO 0·005

Samples.	Mgs. O per litre.	Gold dwt. per ton.	Percentage Gold precipitated.
Entering 1st compartment ..	8·5	0·85	—
Leaving 1st compartment ..	1·5	0·60	29·2
Leaving 2nd compartment .	trace	0·41	31·7
Leaving 3rd compartment ..	trace	0·24	41·4
Leaving 4th compartment ..	trace	0·15	37·5
Leaving 5th compartment ..	trace	0·10	33·3
In discharge pipe from box ..	5·0		
Where it strikes solution surface in sump ..	6·0		
In sump ..	6·0		

It will be noted that the 8·5 mgs. oxygen content is higher than a saturated solution. This manifestly impossible figure is probably due to fading of the colour standards, resulting in high readings. In this table a high degree of precipitation is not reached concurrently with the exhaustion of the oxygen, as in the strong solution precipitation box. It is again noticeable how rapidly the cyanide solution absorbs oxygen after leaving the reducing action of the zinc in the extractor box.

The corollary, suggested by Mr. White's paper, *i.e.*, the effect of a de-aerated solution on cyanide and zinc consumption and on the present objectionable zinc box products in the slime solution precipitation boxes, appears to be a matter for large scale experimentation under our local conditions.

Mr. H. A. White *(Vice-President)*: About the colours. It is a fact that many brown dyes fade rather rapidly, but the dye that I mention in my paper, called "Diamond Brown," I found would certainly maintain its colour sufficiently for over a month if kept in the dark and if distilled water is used for making it. Rand Water Board water coagulates the dye after a short space of time and precipitates a certain portion of the solution as a lime compound. The violet coloration mentioned by Mr. Wartenweiler usually changes within five or ten minutes to the usual brown and may then be compared. I do not know that there is anything more I need say on the point at present. I would just, however, remark in reference to the question of abstracting oxygen from the solutions and the beneficial effect it would have on the white precipitate, and in other directions, I notice, since the paper was written a research has been published* by Mr. T. B. Crowe, in America (who, I believe, is a member of our Society), and that the idea has been developed into what is considered a technical success. The experiments I have myself made of applying a vacuum to solutions would indicate that some special method must be used involving agitation or spraying. This should be investigated speedily, and a grant from the Chamber of Mines is to be suggested.

THE EFFECTS OF DUST INHALATION

By J. S. HALDANE, M.D., F.R.S
(Hon. Member).

(Printed in Journal, July, 1918.)

The President: Since the last meeting, you have all had the opportunity of reading the discussion that took place before the Institution of Mining Engineers, in London, when you will notice the subject created the greatest interest amongst both mining engineers and medical men of the highest standing at home. We had hoped to have had contributions from our local medical men but, as you are aware, they have been so fully engaged in dealing with the epidemic which has been causing such havoc amongst us, that I fear they have not been able to give any attention to the subject at the moment. At the same time, we will welcome the opinions of practical men on the subject.

Dr. J. Moir *(Past-President) (contributed)*: The conclusions to be drawn from Dr. Haldane's paper are of so far-reaching a nature, particularly on the practical side, that I wish to sound a note of caution as to the desirability of confirming the experimental results by means of fresh experimental methods. The experimental work

* See this *Journal*, page 82.

on which the conclusions are based was apparently done before the appearance of a paper by Watkins Pitchford and myself in which we demonstrated: (1) that 99 of the mineral matter in lungs is invisible under ordinary microscopic examination such as presumably was made by Mr Mavrogordato, and (2) that a considerable proportion of what *is* visible consists not of silica but of the accessory highly-polarising minerals of the dust inhaled, these having been mistaken for silica by the earlier observers. Therefore until the experiments are repeated using methods which exhibit the whole of the dust, I prefer an attitude of suspended judgment on the whole question. From the occurrence of these sharp, insoluble and comparatively hard particles of mica, etc., in "silicotic" lungs, it is nowadays obvious that the hypothesis of "free silica" as the sole causative agent in pneumokoniosis will not hold water: apparently every silicate except the talcose and chloritic ones is objectionable, and those which are attacked by cold HCl seem to be the kind that is harmless and even beneficial.

CHRISTMAS GREETINGS.

The President: Nothing remains, as far as the business of the evening is concerned, except, as we shall not meet again till February, for me to take the opportunity of wishing you all a very Happy Christmas and Prosperous New Year and to hope that, when we meet again, we shall do so in the full enjoyment of peaceful conditions, and be full of ideas for future progress.

The Meeting then terminated.

Correspondence and Contributions.

THE CONSERVATION OF MATERIALS.

LAUNDER LINERS.

With the object of bringing to light and record local practical development of satisfactory launder linings, made of cheap and common materials, and in the hope that other members will contribute their experience and knowledge, I am introducing this rather ordinary subject by describing two types of liners:—

Steel Bar Type.—The following description serves to describe a liner used by Mr. F. Cindel at the Durban Deep plant. Reference was made to a liner of this type by J. M. Dixon in our September, 1915, *Journal*:—

The 14 in. × 12 in. launder leading from the return classifiers to the tube-mill cones is lined with discarded 7 ft. lengths of horn liner bars of tapering cross-section; set on edge and laid in cement. The corners of the launder are first filled by a three-cornered wooden fillet and the bars are placed around this U-shaped contour.

Care should be exercised in selecting the bars to have them of uniform size, otherwise excessive wear takes place at the butt joints when a large bar follows a smaller one. This makes a lining from ½ in. to 1 in. in thickness. It is built in during the usual monthly shut down for repairs, and can be placed and in use inside of nine hours by making special provision for drying. This is done by soaking discarded bags in paraffin oil and burning them slowly on top of the newly laid cement.

The slope of this launder is 8·5 , and the pulp flowing over has the following grading:

+60		+90		−90	
74	to 61	14	to 20	12	to 19

Renewals have been necessary after two years' use, at points of division of the main launder; also at the top end, due to excessive wear caused by the high velocity of pulp issuing from the classifier nozzles. With the exception of these points where extra wear takes place, the lining promises to last 18 months' additional to the three years during which it has been in continuous use.

All the launders carrying the mill plate discharge have been lined with this type of liner, and after two years' use show little wear.

The cost of lining 100 ft. of 12 in. × 14 in. launder is estimated at 80s. for labour and material. Approximately 3,600 lb. of discarded steel is used for this distance. The cost of new belt lining for this same 100 ft. would, at present, be seven times as high, and, judging by experience, would last only six months.

Concrete Type.—At the Consolidated Main Reef plant a concrete liner introduced by J. T. Walker has replaced all others for some years. At first concrete U cross-section blocks were placed in the mill launders. During three years of wear only the lining on the bends has been replaced. The wider portions of the launder taking pulp from mill pumps to tube-mill cones (slope 9½°) were lined, bottoms and sides, with 2½ in. thick flat concrete slabs and the narrower parts with U-shaped blocks. Very

few slabs or blocks have been renewed during three years of life. Plate house launders (slope 6°) lining of U-shaped blocks shows little wear after four years' service. The U blocks in the launder conveying the return pulp (slope 8½°) have given 2½ years of service with promise of many additional years. At the head of this launder, where the classifier underflows impinge on the lining, the U blocks last only five months.

The following mixture is used for this concrete liner:—

One part by volume dump waste (mostly quartzite) crushed to ½ in.

One part by volume fine from above crushing (passing ¼ mesh).

One part by volume washed drift sand.

One part by volume Pretoria Portland cement.

The blocks are cast in a long frame holding ten to twelve moulds. After allowing to set and dry for two days in the frame, they are submerged in water for six or seven days and are then ready for use.

The flat slabs are usually 2½ in. thick with length and width to suit requirement. The blocks or section of U cross-section are usually 18 in. long and 9 in. deep and from 11½ in. to 13½ in. wide over all. The thickness at the bottom is from 2 in. to 2½ in., tapering off to 1 in. sides at the top. Blocks to fit bends in the launder are made with the same cross-section dimensions. The average weight of an 18 in. length section is 75 lb.

The slabs and U block are jointed in the launders with quick-setting magnesia cement or with mill blanketing. Either method is satisfactory. When making renewals, the worn blocks are chipped out and replaced by new ones. The discarded blocks are ground in the tube mills and pass into the pulp circuit.

The cost of the U section block, for labour, material and installation can be taken approximately at 20d. per running foot. This is very little more than a 1 in. pitch pine lining with 3 in. × 3 in. angle fillets, and much less than the cost of new belt lining.

In saving of stoppage, in length of life, and in labour of installation the advantage is also decidedly with the concrete liner. Where launders are running overhead, trestle supports usually require stiffening to take the extra load.

The following tabulation summarizes the information on the use of this type of liner:

Description.	Slope of Launders.	Screen Gradings of Pulp.			Life to date.
		+60	+90	−90	
Mill Launders (U-blocks)	7½%	53·55	11·38	35·07	3 years +
Wide Launders conveying pulp from pump discharge to tube mill cones (slabs) ...	9½%	53·55	11·38	35·07	3 years +
Wide Launders conveying pulp from pump discharge to tube mill cones (U-blocks)	9½%				
Overflow Launders from Tube-mills diaphragm cones (U-blocks) ...	18%	9·6	22·4	68·0	2½ years
Overflow Launders from Tube mills diaphragm cones (Bends) ...	18%	9·6	22·4	68·0	4 months
Launders leaving Amalgamation tables (Plate house) (U blocks)	6%	14·2	34·4	51·4	4 years +
Return classifier cones to Mill pulp elevating pumps (U-blocks) ...	8½%	56·8	26·8	16·4	2½ years +
Launder under return classifier cone discharge (U-blocks)	10%	56·8	26·8	16·4	5 months

NOTE.—The + sign has been used to denote a longer life than that recorded, the liner still being in good condition at the time.

Slag liners, made of basic blast furnace slag and cast in iron moulds with reinforcement of discarded battery screening, were rather a disappointment on account of their rapid abrasion, as compared with a concrete liner. Although considerable care was taken in annealing the cast U section by cooling slowly under sand, it was not found possible to overcome brittleness in casting of the comparatively thin cross-section to which a launder lining has to conform.

No particular novelty is claimed for the liners described in the foregoing. The concrete lining maintains quite a smooth running surface, and comparatively little amalgam is trapped by it.

F. WARTENWEILER.

Obituary.

Mr. S. H. Boright.

The death, from pneumonia following influenza, is recorded with much regret of Mr. Sherman H. Boright, B.Sc., at the Lonely Mine, Rhodesia. The deceased was born in Canada in 1881, and was educated at McGill University, Montreal. He came to South Africa in 1905, joining the Society in March, 1908, at which time he was Manager of the Great Eastern Collieries. Subsequently he went to Rhodesia, being identified with the development of the Lonely Mine from the time it was taken over by the company.

Mr. Boright was a valued member of the Executive of the Rhodesia Chamber of Mines, highly esteemed as an engineer and greatly respected by all who knew him. He left a widow and two children to whom the sincere condolences of the Society are tendered.

Mr. D. T. Leonard.

Another victim of the prevailing epidemic is Mr. Dillon Tredway Leonard, an Associate of the Society since March, 1912. Mr. Leonard was connected with the reduction works of a number of mines in Rhodesia, at Gatooma, Bulawayo, Selukwe, and elsewhere.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

The Utilization of Open Hearth Basic Slag.—"Some fifteen months ago Profs. Gilchrist and Louis drew attention to the urgent importance of utilising for fertiliser purposes the vast quantities of open-hearth basic slag which existed or were being produced in this country. They point out that the neglect of this by-product of steel manufacture was due mainly to the circumstance that the availability of the phosphoric acid content was very low as compared with that of the basic slag obtained by the Basic Bessemer process, when both were determined by the citric acid solubility test; that this test is a purely empirical and abitrary one, having no direct relation to field conditions; and that the popularity of the test was to be ascribed to German business acumen, for Germany produced about seventeen times as much Bessemer slag and only about twice as much of open hearth slag as we did, and her steel manufacturers have been able to reap a rich harvest from the sale of this by-product.

In view of the commanding position which Bessemer slag had held hitherto, and of the fact that of the twenty-five firms which make basic slag in this country, only a few produce the open-hearth variety, it was scarcely to be anticipated that any rapid headway would be made at the outset. Nevertheless we are pleased to be able to record that very considerable progress has been effected. A year ago the total production of ground basic slag, available for agriculture, was estimated at 100,000 tons for the period April 1917-18. The actual quantity produced was about 25% in excess of this estimate. The increase was due to the pressure exercised by the Ministry of Munitions with the object of augmenting the quantity of low grade slag which was being ground. This satisfactory achievement was accomplished in spite of many difficulties, among which railway transport and the provision of the necessary facilities for grinding may be specially mentioned. Owing to the concerted action of the Food Production Department and of the Board of Agriculture no trouble has been encountered in getting the farmers to use this slag, and as the demand continues to be much in excess of the supply, there is little doubt that the further increased production forecasted for the coming year will be readily absorbed. In view of the enormous estimated annual production of open-hearth slag, 750,000 tons or more, the above-mentioned increase may not appear to be very great, but it must be borne in mind that much of it is of far too low a grade to bear the costs of handling, milling and transportation, especially at the present time. Seven per cent total phosphoric acid is now regarded as the minimum payable grade, but in point of fact no slag containing less than 8% is now being utilised. Moreover the production of open hearth basic steel in this country is continually on the increase.

That the authorities are convinced of the efficacy of open-hearth slag is evidenced by the order issued on April 30 last. In the third schedule, which gives the maximum prices of ground basic slag, the grade is specified in terms of total phosphate, calculated as tri-basic phosphate of lime, and references to citric solubility are conspicuously absent.

Since the publication of the paper above referred to, G. S. Robertson has adduced additional evidence in favour of the contention that low grade open hearth basic slag and also rock phosphate, when ground sufficiently finely, are valuable fertilisers for pasture land, and that their efficacy cannot be stated in terms of citric solubility. Prof. D. A. Gilchrist, who has done much of the pioneer work on the purely agricultural side, has recently undertaken a series of trials at Cockle Park to determine the relative values (on poor grass land and on soil sown with wild white clover) of high grade basic slag of high citric acid solubility and low grade basic slag of low citric acid solubility, and also the effect of grading up the latter by adding Tunisian phosphate to the contents of the open-hearth furnace.

Practically all the experimental work done up to the present has been performed on grass land and the effect on arable land has yet to be ascertained. At the present time, however, this is not an urgent matter as there is an abundant and increasing supply of superphosphate, the use of which has been restricted to arable land. There is also scope for experimental trials to determine the relative value of low grade open-hearth slag on different types of soil, for there is some evidence that it is more effective on the heavy soils of the north of England than on the lighter soils of the south. In view of the agricultural renascence which is everywhere apparent in this country, there is

the hope that these investigations will be duly taken in hand; in the meantime the fact of outstanding importance is that serious and successful efforts have been made to utilise a by-product which was formerly relegated to the scrap heap, or used merely as a road metal." *Journal of the Society of Chemical Industry*, May 31, 1918, p. 189R. (A. W.)

METALLURGY.

Effect of Oxygen upon Precipitation of Metals.—"Much has been written upon the precipitation of metals from cyanide solution by zinc. We often read of the many factors that influence precipitation, such as zinc surface, purity of zinc, percentage of lead, temperature of solutions, strength of solutions in cyanide or alkali, etc. Little do we hear, however, of the part that oxygen plays in precipitation.

Caldecott* says: 'As the dissolving of gold is essentially an oxidation process, so its precipitation is one of reduction.' All who have studied or worked with cyanide solutions will agree that Caldecott's statement is true. In the cyanide work in the mills of the Portland Gold Mining Co., we have always found oxygen to be the greatest enemy to precipitation.

Oxygen Antagonistic to Good Precipitation.—A few years ago, while making some experiments on the effect of pressure upon the dissolving rate of gold from our ores, to prove a point, I made some bottle tests under vacuum. The results were surprising, and showed that under vacuum practically no gold dissolved, which confirmed my belief that Elsner's equation was true and also led me to investigate the amount of dissolved air carried by solutions at atmospheric pressure.

The experiment consisted in partly filling an acid-bottle with mill-solution and connecting it by a rubber hose to a vacuum pump. When the vacuum was suddenly applied, a cloud composed of thousands of small air bubbles rose out of the solution, showing qualitatively the amount of dissolved air that was contained in the solution, and also proving that the relief of atmospheric pressure on the solution permitted this dissolved air to escape.

In studying literature on the subject, we find Henry's law—'The amount of gas dissolved by a liquid is proportional to the pressure to which the gas is subjected.'

We find that at atmospheric pressure, water dissolves from 2% to 4% of air by volume.

We also find that when air is dissolved by water, owing to the different co-efficients of absorption of oxygen and nitrogen, the absorbed air has the composition of about 35% oxygen and 65% nitrogen, while ordinary atmospheric air is about 21% oxygen and 79% nitrogen. Mill solutions, then, contain not atmospheric air, but a peroxidized atmospheric air, which is very good for oxidizing but very injurious to the reduction process of precipitation.

In the early days of zinc dust precipitation, the dust was sprinkled over the top of a vat of solution while under agitation; large quantities of zinc were used and the solution tailing was far from what was desired.

Later Merrill's improved method came out, the principal characteristic of which was the exclusion of air from contact with the precipitant and precipitate during precipitation. Merrill's method was a big improvement over the old scheme, allowing a material reduction in the quantity of zinc used, with much lower barren solutions, and showed very plainly the effect of oxygen in former work.

Having had the sad experience of allowing free air to pass with my solution through the precipitation press, and knowing that Merrill's process had been an improvement over the old open-vat process, I naturally reasoned that the removal of the dissolved air from solution would be the means of further benefiting precipitation, providing a vacuum could be practically applied to solution, prior to, or during precipitation.

Laboratory tests on the application of a vacuum to solution before the addition of zinc-dust confirmed my theory. Large tests were tried, apparatus was designed that would continuously apply a vacuum to solution during its flow to the precipitation presses, and gradually the vacuum system of precipitation worked its way into our mills, with the result that the zinc consumption has been cut in half, which fact is especially gratifying to us during the war period with its prevailing high prices.

Effect of Vacuum Precipitation on Consumption of Cyanide.—Having been successful in reducing the amount of zinc used, and as the price of cyanide kept soaring, we decided to try to make a reduction in cyanide consumption.

A thorough scrutiny of our former work revealed the fact that, for dissolution purposes on our particular ore, the cyanide solution strength was much higher than was necessary, having been kept high for the sake of good precipitation. In fact, the solution strengths in our mill had been reversed—the strongest solution was the barren; and this being used as a wash on the filters, occasioned high cyanide consumption. The high strength of the barren solution was caused by the necessity of adding lump cyanide at the head of the precipitation process to insure low-grade solutions to be used in washing.

With the installation of our vacuum system, we found that perfect precipitation could be maintained without the addition of lump cyanide, and to-day our mills are running with the highest solution strength in the agitators, and not in the barren vat. This, together with a generally lower solution strength in all parts of the mill, has allowed a material reduction of cyanide consumption.

Table I. will give an idea of the amount of cyanide and zinc used before and after the installation of the vacuum precipitation.

Table I.—*Comparison of Ordinary and Vacuum Precipitation Systems.*

	Tons of Solution Precipitated.	Pounds NaCN per Ton Ore.	Pounds Zn per Ton Ore.	Pounds Zn per Ton Sol.
12 months, year 1915	503,819	0·331	0·407	0·174
12 months, year 1916	536,455	0·320	0·369	0·150
6 months, year 1917	249,988	0·175	0·191	0·084

Years 1915 and 1916, ordinary zinc-dust precipitation. Year 1917, vacuum precipitation.

Opposing Action of Oxygen and Hydrogen.—How often have we found, when working with zinc shavings, that the only remedy for poor precipitation, excepting the addition of lump cyanide to the head of the box (which has its limitations), is a clean-up or redressing of the box.

* "Rand Metallurgical Practice," 1912, p. 389.

Assays of the effluents from the different compartments of a box during a period of good precipitation generally reveal the fact that each compartment in the series is doing some work, there being a gradual reduction of the value of the solution as it progresses from compartment to compartment.

A similar series of assays taken during a period when precipitation is only fair, the box being inclined to give erratic results, shows that the first compartments of the series are doing very little work, the burden consequently being thrown on those compartments lower in the series. A third series of assays, taken when precipitation is bad, generally shows that not only is no precipitation occurring in the first compartments, but that the first compartment is giving up its gold, the values being carried to the lower compartments and sometimes entirely out of the box. Decreasing the rate of flow of solution through the box sometimes helps this condition and increasing the the cyanide strength also gives temporary relief, but a redressing of the box seems to be the only real remedy.

During precipitation, two opposing forces are continually working: first, a precipitating force; second, a dissolving force. The precipitating force is a reducing action and is caused by the dissolving of the zinc, which creates an electro-motive force and evolves hydrogen. Nascent hydrogen seems to be the active agent that causes precipitation. The second, or dissolving force, is an oxidizing action, its strength being a function of the amount of oxygen carried by the solution.

Reducing agent hydrogen and oxidizing agent oxygen are decided enemies, and cannot live together in the same solution. When nascent hydrogen, caused by the dissolving of zinc in cyanide solution, is generated, its first work is that of combating its enemy, oxygen, combining with it and getting it out of the way. After this is done, it then takes up the rôle of precipitation and plays its part.

When large quantities of zinc are dissolved and plenty of hydrogen is evolved, as is the case when lump cyanide is added to the head of the box, the effect of oxygen becomes insignificant, but when the cyanide solution strength is low and very little zinc is dissolved, then the oxygen in solution may gain supremacy over the evolved hydrogen and result in poor precipitation or, in extreme cases, dissolution of precipitated gold. Especially is this true when the zinc has been in use for long periods and the first compartments are rich in gold and poor in zinc. A freshly dressed box presents more zinc surface and, in a cyanide solution of a given strength, has a certain power to reduce and precipitate, this power becoming less and less as it does its work. This work consists of a very small job of precipitating and a very large job of counteracting the effects of oxygen contained in the air dissolved in solution.

Why then allow this enemy of precipitation to pass with the solution into the zinc press or box, when it can so easily be removed by the application of a vacuum during its flow?

When the air in solution is removed prior to precipitation and the deoxidized solution is run or pumped through the precipitating system, only the burden of precipitating is put upon the zinc and we find, when this is done, that a very weak electro-motive force is sufficient to effect precipitation, which means that one can operate with both weaker cyanide solution strength and with smaller amounts of zinc, producing a higher grade precipitate with less cost for cutting down and refining." T. B. Crowe, E.M. Trans. Amer. Inst. M.E., Aug., 1918, p. 1279. (H. A. W.)

MINING.

Air Blasts in the Kolar Mines. (Air blasts, quakes and explosive rock are terms used to indicate the phenomena that accompany failure of rocks under unusual strain in mining operations. Although usually associated with deep mining, there are examples that occur in comparatively shallow mines. The paper presents a description of the geological formations and the 'air blasts' in the mines of the Kolar gold field. The causes of the blasts are discussed.

The Kolar gold field has been for a long time the most important gold-producing area of India. It is in the State of Mysore, Southern India, and not far from the City of Bangalore. The productive field is about three miles long, and in it a gold-bearing quartz vein varying in width from 1 in. to over 10 ft. is worked. In some places the vein is highly folded and the schist in the vicinity of the quartz is, as a rule, fine grained. It likewise shows evidence of a strained condition.

Description of the Air Blasts.—In the Kolar field the air blasts occur in the quartz vein, trap dikes or the hornblende-schist, being most frequent in the quartz. They bear a strong resemblance to the explosion of a small charge of powder placed in the wall of the workings, because in some cases the rock blows out from the solid face of the drift or stope as a puff of rock powder, while in others small fragments are shot out with sufficient force to scratch and severely cut the miners. Often a continuous crackling and snapping are kept up at the fresh working face, interspersed with explosions like those of small detonators. The explosions do not bear any definite relation to the depth of the mine, after a few hundred feet in depth has been reached, and they are therefore independent of the superincumbent weight of the rock in the mine workings. They have occurred during the sinking of the large circular shaft on the Mysore property, in very compact hornblende rock, and less than 700 ft. below the surface. In some of these explosions large masses of rock were blown out with loud reports, and one was mentioned in which it was estimated that 80 tons of rock were precipitated from the wall, making it necessary to employ a shield to protect the workmen while sinking the shaft.

Air Blasts Resemble Earthquakes in Kolar Mines.—The term 'quakes' has been employed by Dr. Smeeth in his excellent work on these phenomena to describe the heavier shocks which occur in the Kolar mines and produce effects at the surface in all respects like those of local earthquakes. In some cases these shocks have been sufficiently severe to be felt at a distance of nearly four miles from their point of origin. They have been destructive to mine structures and in some cases to the lives and limbs of the miners. One case is described by Smeeth in which a block of rock, the weight of which was estimated at half a ton, was hurled with a low trapectory from end to end of a stope 30 ft. in length. In some cases the footwall of the vein, which usually lies on a slope of 50° to

60°, buckles up and large masses peel off with considerable violence.

As a rule, these larger shocks, or 'quakes,' occur in the deeper levels and in areas where considerable stoping has been done. They are particularly prevalent where quartz pillars have been left to support the roof of the workings, and they seem to owe their origin partly to the superincumbent load of rock in the workings, but their violence can only be ascribed, like that of the air blasts, to some latent energy or strain in the rocks of this area.

Causes of the Blasts.—Various explanations have been offered to account for these explosions. For the Hillgrove mines (New South Wales) Jaquet has mentioned the following hypothesis: (1) molecular strain, (2) occluded gases, (3) compression due to intrusion of granite, or other causes. He concludes that the rocks must be under great strain, and, being unable to bend, they must break suddenly under certain conditions. He apparently does not favour the granite intrusion hypothesis and dismisses entirely the idea that occluded gases might cause the explosions. Regarding the air blasts in the Pribram mines, in Bohemia, Stefan states that 'the conclusion seems justified that the cause of these explosions is not only the pressure of the superincumbent rock-mass, which is at right-angles to the strata, but is due also to a stress parallel to the bedding planes and to the axis of the syncline.'

For the Kolar field, Bosworth Smith considers that the air blasts are due to a molecular strain in all three of the rocks, trap, schist, and quartz, and he likens the explosion which occurs during mining operations to the breaking of a Prince Rupert's glass drop, which is a mass of glass under severe strain caused by sudden cooling. As to the cause of the strain, he considers that the quartz is compressed by the walls of the vein through regional pressure, and not simply by the weight of the overlying rocks, while the trap is under strain because of sudden cooling and the hornblende schist because of metamorphic changes which have given rise to the calcite, forming stringers through the rock.

Smeeth agrees with Smith regarding the origin of the strain in the trap dikes, because, as he states, there is no evidence that the dikes have suffered extensive compression since their solidification. As to the possibility that metamorphic changes in the schist produced the strain, Smeeth points out that the chief change has been the alteration of augite to hornblende, and since this change is facilitated by pressure, there is reason to suppose that the compressional strain would be relieved rather than increased. Further, the compressional strains in the schists produced by the intrusion of the surrounding granite and the injection of the dolerite dike would be relieved by the later cooling and shrinkage of these rocks, and the strain in the schists would be tensional. Regarding the strain in the quartz, Smeeth is of opinion that it is also tensional, partly because of the fact that there are secondary stringers of calcite, quartz, and metallic minerals in the reef, suggesting that the rocks have suffered sufficent tensional strain to open joints and permit the filling of these with mineral matter.

Conclusions Regarding Blasts in the Kolar Field.—After observing the rocks in the Kolar field and considering the descriptions of the air-blast phenomena in the other regions which have been mentioned, I have come to the following conclusions regarding their origin: They are due to a stress on the rocks, which has produced a strain, and under mining operations this strain results in a violent rupture. In the case of the larger shocks, which Smeeth calls 'quakes,' the violence with which pillars and other supporting masses give way in the workings under the superincumbent load is due to a large extent to this internal strain.

As to the cause of the stress, the only satisfactory explanation is the application of pressure resulting from crustal movements. At Pribram the blasts occur in the flat-lying strata of the syncline and not in the upturned beds in which the strain has been relieved by faulting and tilting. In the Hillgrove mines, although the geological description by Jaquet is not detailed, it is evident that the slates have been intruded by masses of granite. In the Kolar region, the older rocks, in which the quartz vein lies, are surrounded by granite and nipped in by it in a closely compressed syncline. There thus seem to be in all these fields certain similar conditions pointing to the fact that the rocks in which the blasts occur have been subject to great compressional forces. As to the ability of the cooling dolerite dikes to produce sufficient tensional strain to cause the explosions, this seems doubtful.

The spheroidal weathering and fracturing described by Smeeth as probably supporting this view is a characteristic feature of such basic rocks in many regions and does not warrant much consideration. The greater facility with which the fine-grained edges of the dikes will explode is what would be expected under normal conditions, since the rock would be more brittle in those parts of the dikes, just as the silicified slates and schists in the other regions described would be more brittle and would crack up more readily than the other parts of the same rocks. Nor does the tensional hypothesis adequately explain how the heating of the schists and quartz by the intrusion of the later rocks could produce tension in these rocks unless it can be shown that a complete change in the molecular character of the rocks was produced by this heating, and such evidence appears to be lacking. If the heating converted augite into hornblende, the resultant increase in volume of over 4% would cause expansion rather than tension; whereas, if rocks simply expanded by heating they would contract again to their normal condition on cooling.

It also seems probable that the crystallizing of the quartz vein may have exerted some expansive pressure on its walls. As to the occurrence of the small secondary quartz and calcite veins, they may be accounted for by torsional movements in the rocks, which are still, on the whole, under great compressive stress. The rocks in the mines are not uniformly explosive, and such an explanation would account for this condition. In some places the rocks have opened through torsional movements and in others they have yielded to compressional forces, which have produced the movements indicated by the slickensides, while in still others they have not been compressed sufficiently to cause them either to shear or to rupture, and in these spots the potential energy gives rise to the blasts. Such a condition is particularly likely to arise in a region where heavy dikes intrude rocks of varying compressive strength and brittleness.

The force which compresses these rocks may be due to two or more causes: (1) Epirogenic movements in the earth's crust, due to adjustments of stresses over considerable areas of the earth's crust, with accompanying igneous activity; (2) general settling back of considerable areas of the crust during adjustment after the eruption of large amounts of igneous rock from certain portions of the crust. Such forces might easily obliterate the results of all contraction and relief of pressure in the rocks of the area by cooling, and to such forces as these the strain producing the air blasts is attributed.

In this field a well-equipped seismological laboratory has been established and complete records of all shocks are kept. The effects of the heavy shocks are similar to those of local earthquakes. Some of the officials at the mines have been anxious to have a number of tests made on the rocks of the region to determine their elasticity, crushing strength, and other properties, and I have endeavoured to have such tests made, but so far, partly owing to war conditions, have been unable to accomplish this work."—E. S. MOORE.—*Engineering and Mining Journal*, May 25, 1918, p. 957. (H. A. W.)

MISCELLANEOUS

ART OF INDUSTRIAL DISCOVERY. BRITISH SCIENCE AND THE FUTURE.—"What is to be the industrial future of Britain? Into that one question so many others are packed that one could fill a column with the mere list of them. But when I went to talk to Sir Robert Hadfield, who is, I suppose, the foremost metallurgist of this country, I was thinking chiefly of the future as compared with the past, and of that old dependence of ours on Germany from which the war has set us free. Shall we retain that freedom, or shall we in the coming years go back to the old ways? Have we in this country the men who can make us permanently independent of German scientists?

'I have yet to learn,' said Sir Robert when I put the question to him, 'that the German scientists are superior to our own. Germany never was ahead of us except in the application of knowledge. There is no evidence that Germans are, or ever were, ahead of us in research or ingenuity. The German people are very industrious. In the years before the war they proved that they were willing to spend years of work on any line that was suggested to them. They were ready to take any hint, to follow up any clue, but they have no monopoly of inventive genius.

'Their eagerness to learn has always seemed to me their chief characteristic. I know that Krupps kept an eye on every periodical in the world that dealt with steel. Their arrangements were so perfect that they could not miss any important fact that found its way into print anywhere. And that is how the Germans scored. They pressed the brains of all the world into their service, and the curious fact is that the world has been deluded into thinking that the consequent progress was solely due to the superiority of German brains.

Life has been too easy. 'Some of us knew before the war that the British had brains of their own, but it has needed the war to bring that fact home to the mind of the nation. There is that excellent British Scientific Industries Exhibition at King's College. It has been a revelation to very many people. They had no idea that British scientists had achieved so much or that British industry was capable of so much, but the achievements of our scientists are not new, and British industry was always capable of the things which it is performing to-day. The fact is that life has been too easy for us in the past. We did not take our work seriously enough and we did not care if others reaped where we had sown. Our scientists made discoveries and Germany exploited them, and was given the credit for them.

'In these years of war we have been compelled to learn our own power, and that exhibition is the proof that now at all events we are awake to it. Every time I have been to King's College since the exhibition was opened I have been struck by the number of people in the rooms and by the care with which they study the exhibits. There is nothing attractive about the show. There are no cinematograph displays, nor is there anything in the nature of entertainment. But there are always people going round, studying their catalogues, asking intelligent questions, taking notes, and showing the most genuine and instructed interest.

The Obsession of Letters. We have suffered in the past from the obsession of letters. Oxford and Cambridge have concentrated on letters and mathematics and they have neglected science. It has been left to the local universities to rectify that error and to a great extent they have done it. In our works at Sheffield we know the value of the men who are trained at Sheffield University, and we employ many of them. The success of the local universities in turning out men apt in scientific work has made it clear that we have in England no lack of the raw material of which scientists are made.

'But the trouble is that there is so little recognition of the scientist. We live in an industrial age. Consider for a moment and think what the world would be like if you took away iron and steel. What would become of our houses, our towns, the whole fabric of our life? The world of to-day is built on a foundation and framework of steel, and the scientist is the master of steel as well as of all those other material things which play a part in life. But the scientist has scarcely any part in the government of the country. The highest places and the greatest rewards appear to be reserved for those who are quite definitely not scientists. There is scarcely any organization at work seeking out and helping embryo scientists, and it has to be confessed that the boy or girl who in England wins through to scientific competence—to say nothing of eminence—does so in spite of rather than because of our system of education.

'That is one of the things we have to change. This war has made plain the importance of the scientist even to those who in the past thought little of science. We owe our favourable position to-day to the fact that there have always been in England men who have devoted themselves to scientific studies and to research, very often without hope of reward, very often in the face of discouragement. But it is neither sensible nor fair that this state of things should continue. If we wish to retain our position we must set to work deliberately to cultivate our scientists, to seek them out and to train them and to cherish them.

The Organization of Discovery.—'For there is nothing accidental about scientific discovery or

invention. Scientific discovery is an art which can be cultivated, as the late Dr. Gore showed in his wonderful book, 'The Art of Scientific Discovery.' Important discoveries cannot be made by rule alone, but the process of scientific discovery can be largely reduced to order and rule. And it must be obvious that the man who has been trained in the rules and practice of this art is infinitely more likely to make valuable discoveries than the untrained chance experimenter. Discoveries which win wars and establish a nation's industries are not lucky flukes. They are nearly always the results of work along certain definite lines—work which can only be carried out by men who have been trained to perform it.

"In the years to come we shall need all the discoveries, and therefore we must provide ourselves with discoverers. British scientists have always been among the foremost in the world, and we have to ensure that they always shall be. And that, it seems to me, is one of the great lessons which the war has to teach this country. In the past we left nearly everything to chance, but that will not do for the future. We cannot afford to run such a risk again, neither can we afford to allow the industries which are our strength to depend for their progress on the devotion of the few or the toil of those who are so often unrecognised and unrewarded.

"If we will do this, if we will find, train, use, and reward our own men, there should be no question of any kind of dependence on Germany in the future for scientific products, or any fear of German competition in the industrial world."—H. L.—*The Observer*, Sept. 15, 1918.

Abstracts of Patent Applications.

313.18. W. E. Nettle (1), Paul Selby (2), J. H. Holman (3). Improvements in packing rock drilling tools in drill chucks. 10.6.18.

This application is in respect of a method of making a water-tight joint between the chuck and the drill shank in rock drills where a hollow steel is employed for drill bits and water passed through same.

A recess is formed in the chuck, and a rubber ring through which the drill shank is passed is placed in this recess. The recess is made wider than the rubber ring, which can spread out into the recess when the drill shank is pushed through it.

314.18. W. E. Nettle (1), Paul Selby (2), J. H. Holman (3). Improvements in rock-drill chucks. 10.6.18.

This application refers to a form of chuck for rock drills. It is proposed to make the chuck a separate piece and to secure it to the drill piston rod by a tapered hole into which the end of the rod is fitted.

This chuck is to be made of a hardening steel, and to be suitably tempered after machining.

It embodies the annular groove and the rubber ring described in Patent Specification No. 313/18 by the same claimants.

Slots are provided in the side of the drill socket to receive wings on the drill shank.

The drill shank is secured by a pad let into the head, bearing on the shank and on the wings of same and secured by U bolt and wedge.

An alternative claim is that a chuck as described may be forged solid on the piston rod instead of being a separate piece.

316.18. R. Harbottle (1), S. Siverton (2). The production or manufacture of acetic acid from certain indigenous trees. 11.6.18.

The applicant claims a process which consists in placing the wood after it has been dried and cut into suitable lengths into suitable retorts which are heated externally, and further to make a fractional distillation in order to separate the methyl alcohol and acetone from the acetic acid, all being present in the aqueous solution obtained from the first distillation, or to distil it only in a solution of milk of lime thus obtaining lime acetate.

346.18. P. Poore. Improvements relating to the distillation of wood, woody fibre, peat and similar carbonaceous substances. 1.7.18.

The applicant claims a new method for the distillation of wood, peat, etc., which consists chiefly in; (1) cutting the wood into small pieces; (2) reheating it to drive off the excess moisture; (3) the use of waste gases for this purpose; (4) external heating of the retorts at first, and finishing the distillation by admitting steam into the retorts. Finally, he claims a special apparatus for carrying out the above process.

408.18. E. A. Ashcroft. Improvements in the carbonization of coal or the distillation and cracking of shales, peat, oils, pitches, or other carbonaceous materials. 19.7.18.

The main feature of the process of the distillation is by suspending or injecting the material in a fused or freely mobile salt in a converter and by blowing in air, or hydrogen, or nitrogen or ammonia and other gases.

419.18. C. Turner. Improvements in processes of destructive distillation. 24.7.18.

The applicant claims improvements in processes of destructive distillation of carbonaceous materials such as wood, peat, lignite, oil shale, coal, etc.

521.17 and 171.18. W. Mauss. Improvements in operating mechanism for centrifugal filters. 20.3.18.

This application is for a centrifugal filter in which the separating and filtering vessel is formed of two hollow cone shaped sections, which are firmly held with their larger ends forming a tight joint, during the period of separation, and which are capable of being lowered to a separate chamber and the two cones opened for the discharge of the solids, without stopping the machine. Means are provided for regulating the periodicity of the discharge, filtering and charging operations through automatic mechanism.

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APR 2 5 1920
UNIVERSITY OF

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

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Vol. XIX DECEMBER 1918. No. 6.

DETERMINATION OF AVAILABLE CaO IN THE DIFFERENT CLASSES OF LIME SUPPLIED TO RAND REDUCTION WORKS.*

By C. A. MEIKLEJOHN (Member).

The object of the work embodied in the following notes is to present as briefly and simply as possible the results of investigations carried out at the Metallurgical Laboratory of the Rand Mines, Limited, to determine some points which have arisen in our experience in connection with the determination of available CaO in the samples of lime supplied.

The method originally in use at the laboratory was, with slight modification of crushing the sample to −90 instead of −60, that described in the pamphlet issued by the South African Engineering Standards Committee of date January, 1913.

It is as follows:—

Determination of "Available Alkalinity" (CaO).

The sample as delivered for analysis is contained in an air-tight vessel, having been passed through a 30 mesh sieve as stated above. It is crushed with a Wedgwood mortar and pestle and the whole passed through a 60-mesh sieve; this operation being performed as quickly as possible. It is then placed in a clean, dry, wide-mouthed bottle fitted with a tight-fitting dry glass stopper so as to prevent any access of air. Two gm. of this are carefully weighed out and agitated with 1 litre of a 2% cane sugar solution (or 1 gm. with ½ litre of 2% sugar solution). If a shaking machine is available, two hours' continuous agitation should be given; if not, 6 hours' intermittent agitation, every care being taken to prevent coagulation of the lime, in order that the lime and solution may be brought into the most intimate contact during this period. When the agitation is finished the solution is filtered as quickly as possible, and an aliquot portion titrated with N/10 or N/5 acid, using rosolic acid as indicator, avoiding delay so as to obviate undue exposure to the atmosphere.

NOTE.—The distilled water used in the above determination must be made neutral to rosolic acid to counteract the presence of dissolved CO_2.

This method, though apparently clear and straightforward, we found to be full of pitfalls and to give low results. After considerable investigation, the following method was adopted for unslaked lump lime; the same method was also adopted for slaked and slaked air separated lime, with some slight modification to be mentioned further on. The results, so far, have been satisfactory.

(1) The whole of the sample is passed through a disc pulveriser, and a relatively small portion taken and ground fine in an agate mortar.

(2) Two gm. of the agate ground sample is added to a Winchester quart bottle containing 1,000 cc. of 2% sugar solution in distilled water with sufficient lime water added to neutralize any CO_2 present to phenolphthalein.

(3) Agitated intermittently for two hours. This intermittent shaking means that one native may have anything from six to eighteen samples to shake during this time.

(4) The sample is then allowed to stand overnight, and a measured portion of the clear solution drawn off without filtering and titrated with N/10 sulphuric acid, using rosolic acid as indicator.

*This paper will be introduced and discussion invited thereon, at the February meeting.

Although there is nothing novel in this method of procedure, a description of the work carried out may be of interest.

1. *Fine grinding.*—Although grinding the sample to −60 mesh was considered by the Standards Committee to be sufficiently fine, by common consent the agate grinding of the portion of sample for analysis would appear to be considered advisable if all the available CaO is to be taken into solution. In any case, the finer crushing in the agate mortar should ensure more intimate contact of the lime with the sugar solution. It is, of course, understood that no time is lost unduly in the preparation and weighing out of the sample, and that during this time it is excluded as much as possible from contact with the air.

2. *Neutralizing of CO_2 in distilled water used.*—The only difference here is the substitution of phenolphthalein for rosolic acid as indicator. When neutralizing the CO_2 our practice is to add two or three drops of an 0·5% solution of the indicator to each test and neutralize each one separately. It has been suggested that the presence of an indicator during agitation tends to give low results, but such has not been our experience.

3. *Time of agitation.*—According to the method laid down by the Standards Committee the time for agitation of the lime sample with the sugar solution should be either two hours' continuous or six hours' intermittent agitation. Not having an agitation machine, and wishing to adhere as religiously as possible to the method laid down, we, at first, agitated intermittently for six hours. We had reason to believe that this time was excessive and favoured low results. As a consequence a series of tests were made to determine the most suitable time of agitation. It was found that, generally, the maximum results were obtained with two hours' intermittent agitation, and that agitating beyond this time gave low results. The following table will illustrate this.

The solutions were titrated with decinormal sulphuric and hydrochloric acids, the results being practically identical in each case. With the exception of Series 3, where the highest result was obtained in one hour, maximum results were obtained with two hours and minimum with six hours' intermittent agitation.

Amount of sugar required.—2% solution of sugar would appear to be the minimum for 2 gm. of unslaked lime per litre. To ascertain this a series of tests were made as under:—

TABLE I.

No. of Series.	Lime taken for test, grams.	Time of Agitation, Hours.	Volume of 2% Sugar Solution.	CaO found per cent.
1	2	1	1000 cc.	84·26
1	2	1½	do.	84·56
1	2	2	do.	84·70
1	2	2½	do.	84·56
2	2	1	do.	67·62
2	2	1½	do.	67·76
2	2	2	do.	68·04
2	2	2½	do.	67·48
2	2	3	do.	67·50
2	2	6	do.	66·92
3	2	1	do.	78·40
3	2	1½	do.	78·26
3	2	2	do.	77·84
3	2	2½	do.	77·42
3	2	3	do.	75·50
3	2	6	do.	76·30

TABLE II.

2 gm. lime to each test.
Volume of solution, 1,000 cc.

Weight of Sugar, grams.	Time of Agitation, hours.	CaO per cent. in unfiltered solutions after standing 3 hours.	CaO per cent. in filtered solutions.	CaO per cent. in unfiltered solutions after standing overni
10	3	79·80	76·30	76·30
15	3.	84·28	81·34	81·20
20	1	—	84·28	—
20	1½	—	84·56	—
20	2	—	84·70	—
20	2½	—	84·56	—
20	3	—	83·80	—
25	3	85·26	84·00	84·14
30	1	—	84·28	—
30	3	85·26	83·86	84·00
20	¼ hr. and occasionally for 3 hours.	85·54	84·00	84·00

It will also be seen that practically identical results were obtained when the solutions were filtered and titrated directly after agitation or when the titrations were made on the clear unfiltered solution after standing overnight.

It is hardly necessary to labour the point of filtering the solutions or allowing the same to stand until perfectly clear before testing. Testing the unfiltered solutions even after allowing to stand for three hours gave results as much as 3·5 CaO in excess of the true value of the sample.

Effect of filter paper on CaO in solution.—Although the adsorptive effect of filter paper on alkaline solutions is fairly well known, the effect of same on CaO in sugar solutions is perhaps not so well known. We found that the amount of solution required to saturate a filter paper before taking portion for testing varies with the size and make of the paper, some papers requiring considerably more than would have been expected.

TABLE III.

No. of Series.	Weight of sample taken, grams.	Order of test and volume of solution taken.	CaO found per cent.
1	2	(1) 50 cc.	70·28
1	2	(2) 100 cc.	70·70
1	2	(3) 50 cc.	71·26
2	2	(1) 50 cc.	70·00
2	2	(2) 100 cc	70·42
3	1·4	(1) 100 cc.	70·20
3	1·4	(2) 50 cc.	70·80
3	1·4	(3) 100 cc	71·00
3	1·4	(4) 50 cc	70·80
4	1·4	(1) 100 cc.	70·20
4	1·4	(2) 50 cc.	71·00
4	1·4	(3) 100 cc	70·80
4	1·4	(4) 50 cc.	71·00

The above were all made on 1,000 cc. of 2 sugar solution.

Time of agitation, three hours.

After agitation the solutions were filtered, the first 50 cc. being rejected, and successive portions taken as above for testing.

It will be seen that differences up to 1 were obtained on titration of successive portions from the same solution, the differences being greater with the later portions of the solutions. The filter papers used were 30 cm. diameter, and it would appear that, with a paper of this size and make, at least 250 cc. of the solution should be allowed to pass through the paper before taking the portion for testing.

Modification of method with slaked and air-separated lime.—As previously mentioned, a modification of the forementioned method is used in testing samples of slaked and air-separated limes. The modification lies in the treatment of the sample before taking the portion for assay, as follows:—

"The top layer of, say, 1 in. is removed from the sample and rejected. The balance of the contents of the tin is rapidly and evenly spread on a sheet of paper, sampled with a spatula and a portion for assay ground in an agate mortar to reduce the coarse particles."

It may be suggested that this is an unnecessary refinement, and that the slaked and air-separated limes—particularly the latter—are sufficiently finely divided to sample directly from the tin. This may be so under certain conditions, but we have found that with samples submitted to us duplicate tests by sampling directly from the tins gave results varying by as much as 8·2, as shown below:—

	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
Original result...	55·2	54·9	48·5	46·0
Repeat 1 ...	49·6	55·2	53·2	50·1
" 2 ..	47·0	50·1	—	—
" 3 ...	47·9	54·3	55·5	—

It was evident that some method of sampling less open to criticism would have to be adopted, and to this end comparative tests with different methods of sampling were carried out on a sample of "Tannys" air-separated lime. As a preliminary, the top layer of about 1 in. was removed and rejected, and the balance of sample treated as under:—

(*a*) Sample dipped directly from towards bottom of tin. No grinding.

(*b*) Mixed in tin. Hole made in centre. Sample taken from side of hole and ground in agate mortar.

(*c*) Contents of tin spread out on paper. Sample taken with spatula and ground in agate mortar.

(*d*) Balance of sample passed through disc pulveriser.

Four determinations were made in each series. The results were as follows:—

	(a) Per cent.	(b) Per cent.	(c) Per cent.	(d) Per cent.
1	50·4	49·9	49·9	50·4
2	49·9	48·5	48·2	48·8
3	47·4	47·9	49·0	49·0
4	46·8	47·1	50·2	48·2
Average ..	48·7	48·4	49·3	49·1
Max. difference...	3·6	2·8	2·0	2·2

The most concordant results are obtained from (*c*) and (*d*), and of these (*c*) possibly lends itself to less abuse than (*d*).

A number of additional tests were made to further investigate the effect of passing these slaked and air-separated limes through a disc pulveriser; also the time of agitation necessary. We invariably found (1) that the CaO content was lower after passing the pulveriser and (2) that samples of white slaked limes from Taungs required longer time of agitation than the Northern slaked limes. As a result of this and the work previously described, the forementioned modification was made with two hours' intermittent agitation for "blue" and three hours for "white" slaked and air-separated limes.

Much of the work described in the foregoing may appear to have been unnecessary. We have had to investigate, however, practically every step to determine the cause of the low results obtained when using the method described by the Standards Committee and which, by the way, does not appear to be followed generally by the local analysts.

In conclusion, it would appear that the main points to emphasize in connection with the estimation of available CaO in lime samples are:—

(1) Sampling of slaked and air-separated limes.

(2) Time of agitation.

(3) Treatment of solution after agitation.

According to our experience the most consistent results are obtained with two hours' intermittent agitation (three hours with Taungs slaked limes) followed by settlement overnight before titration. If it is necessary to titrate the solution directly after agitation, care must be taken that sufficient of the solution is passed through the filter paper before taking the portion for titration.

The points raised in this paper are simple, and doubtless are well known to many of the members of the Society; but they are not well known to all, and the writer will be glad if these notes are found to be useful to those engaged in or responsible for the valuation of lime for commercial purposes.

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Mr. Fred. Wartenweiler *(Member of Council)*: Although Mr. Meiklejohn's paper is on a rather old subject, and one which has been the subject of a great deal of discussion by the members of this Society as disclosed by the bibliography, it appears to me, it will prove of value to those who are purchasing lime by the "available CaO unit" basis. These sort of investigations involve an amount of work and time usually unappreciated by the casual reader and, I think, we are considerably indebted to Mr. Meiklejohn for his labours and for further light on the subject. The aim which he has in view, the agreement among lime suppliers and analysts on a uniform method, based on experience, is to be applauded. I say "based on experience," because I believe that the method which gives consistent results by actual experience, which avoids the pitfalls mentioned in the paper and which decreases or steadies the personal error, which to the best of my knowledge exists in all available lime determinations, should be adopted.

Obituary.

Mr. B. Palmer Carter, E.M.

It is with profound regret the death from heart failure is recorded of Mr. Benjamin Palmer Carter, the Manager of the Robinson Gold Mining Co., Ltd. For a number of years the deceased had not been in robust health, and about a year or so ago he

survived a serious attack of pneumonia, coupled with the disease which claimed his life on the 11th December. Mr. Palmer Carter, who was born in New York 46 years ago, had been on the Rand some 23 years, and had occupied various positions on the Crown Deep and the Langlaagte Deep, becoming Manager of the Ferreira Deep after the South African war, and for the last seven years holding the position of Manager of the Robinson Mine.

Mr. Carter joined the Society as a member in April, 1903, was elected a Member of Council in June, 1903, becoming Vice-President in 1905, after which pressure of other duties prevented him from again taking an active interest in the Society's work, although contributing to the discussions on various papers on several occasions. The Society was officially represented at the funeral, which was largely attended, at Brixton cemetery on the 6th December, by the President and Secretary. The deepest sympathy of the Society has been conveyed to his wife and children and his sister (Mrs. Otto Beit) in their bereavement.

Mr. Carter was predeceased by his brother, Mr. T. Lane Carter, who was equally well known on the Rand, in 1912.

Mr. John McPherson Campbell.

The death is recorded with deep regret of Mr. J. M. Campbell, Mill Foreman at the Robinson Deep, Ltd., on the 13th December, from influenza.

Mr. Campbell, who was 46 years of age, joined the Society in December, 1909, and was a careful and conscientious worker, highly esteemed by his colleagues.

REPORT ON ECONOMIES IN MINING ENGINEERING SUPPLIES.

During the year 1916, the tightening up of restrictions in England on the export of supplies for the mines made it imperative that concerted action should be taken regarding economies to be practised on the mines and, where possible, have substitutes for imported articles made locally.

Previous to that year the large local stocks of necessary engineering supplies had not made the matter so urgent, but certain economies and useful ideas were being developed on individual mines, and it was evident that, providing a free circulation of this information could be accomplished, the mines of the group would be greatly benefited.

Many interesting and unique devices in connection with machinery on mines were evolved by various engineers, and it was felt desirable to summarise the many economies which had been effected.

The following is a list of the principal items :—

MILL PARTS.

1. Stems :

Stems are made on many mines from old camshafts or by faggoting up three old stems, at a cost averaging about £3. Stems are also repaired by welding on any suitable scrap material. Many mines report that one or other of these ideas has long been practised.

2. Cams :

New Modderfontein.—Worn cams are brought up to shape by welding on pieces of rail or drill steel, at a cost of about £2 10s. per cam.

The Knight Central fuller up the cams and, when necessary, weld in a piece of drill steel. The cost is stated to be £1 per cam.

Many mines are putting this process into practice.

Ferreira Deep, Limited.—Draw out old worn cams from root to standard size. In practice prior to war.

Crown Mines, Limited.—Have made up a few by quasi-arc, first results not good, could be improved.

3. Heads :

Ferreira Deep, Limited.—When badly worn in socket are heated up, compressed, re-bored, and put again into commission.

4. Shoes :

Several methods are being tried for replacing broken shanks on shoes.

New Modderfontein weld a worn-out shoe on to the broken one. This is economical if the weld holds, but definite information on this point is not yet available.

A more usual method is to draw a new shank out of the shoe under hammer, which makes a satisfactory job, not, however, invariably successful, variation in quality of steel sometimes causing the shoe to split. It is stated two hours are required to form a new shank like this, so the cost would be about 10s.

Rose Deep bore out shoe and shrink in a mild steel shank at a cost of about £1.

Another mine converts old tappets into shoes by welding on a shank.

5. Dies :

It is now general practice to make dies by cutting an old head in two and filling holes with shoe shanks. This costs about 15s. for two dies.

6. Cam Shafts :

Witwatersrand Deep, Limited, make cam shafts of five stems faggoted up together. Other mines weld up broken cam shafts, with varying success.

7. Blanton Gibs :

Crown Mines, Limited, has found a gib with feather on key much superior to the gib with two pins. The holes for pins are frequently drilled too deep and become a source of weakness in cam shafts. The keyway would appear to add 50% to life of cam shafts.

Ferreira Deep, Limited.—All pin-holes in cam shafts are drilled in fitting shop to gauge ¼ in. deep, by using flat-faced drill with sleeve on to prevent possibility of drilling too deep, therefore consider cutting key-ways and fitting key an unwarranted expense.

8. Mortar Box Liners :

At the Crown Mines, Limited, mortar box liners are made from old cam shafts, at a cost 50% under imported ones. Similar liners are being made on some of the mines from old dies.

9. Wood Guides :

In connection with the practice of re-boring wood stem guides, the Knight Central, Limited,

find it pays to buy extra thick timber for the outside guides. In this mill the inside guide against the girt cannot be more than 1 in. thick, but the outer one can be 1½ in. This extra ½ in. gives a much longer life to half the guides.

Ferreira Deep, Limited. Practice on mine to start guide with ¾ in. liner between halves, and as holes wear the liner is reduced until they come face to face. ¾ in. is then cut away from the face of each half of guide block and restarted with a ¾ in. liner. Same procedure carried out until blocks are completely worn out; any odd hole worn out of proportion is lined with raw hide liner. By this method get an average life of seven years. Other mines adopt similar methods for economies in guide blocks.

Crown Mines, Limited.—Reduced our bill by lining guides with discarded leather ("Hendry") belting. Leather lining is not a new idea, but tacking on strips is novel, having advantage of enabling shape of box to be maintained. Still further improved by battery screening.

10. Boilers:

An interesting boiler repair job, which saved the company an expenditure of £300 on the boiler tubes, was carried out at the New Heriot Gold Mining Company, Limited. Through removal for cleaning, the tubes of an F. & C. boiler, 104 in number, had worn out at the ends. By cutting 2 in. off each end of these tubes and 1 in. off the boiler shell, all these tubes could be used again. The whole job cost £60.

East Rand Proprietary Mines, Limited.—Method new to mine, but do not approve. It is practice to cut and weld tubes to suit the boiler and consider this better method. Welding tubes in practice on mine since war started.

Crown Mines, Limited.—Shortening of boilers has been in practice with Sterling boilers in order to make further use of tubes, also being done to facilitate transport.

11. Bye-Pass Valve:

A bye-pass valve for Sulzer pumps is made by Mr. Hird, *Durban Roodepoort Deep, Limited*, which eliminates the wasting of the whole of the valve casing when the seats are grooved.

The seating and valve can be renewed without breaking any joints except the top cover, and can be changed with valve in position.

Robinson Gold Mining Company, Limited.—Designed one last year of simple type doing well. Suggest making seat removable in way to save bringing to shops. Then alter dimension a little so valve could be renewed by taking off cover only.

Knight Central, Limited.—Great economy has been effected by placing a worn valve outside the good bye-pass valve by closing the worn valve first. This has the effect of balancing the pressure when closing the inner valve. The life of valves is greatly prolonged for the cutting effect of water under pressure is greatly reduced.

12. Charging Sticks:

East Rand Proprietary Mines, Limited.—Have locally made machine of revolving tube carrying two cutter blades. Sticks squared and passed through centralising guide slot on to cutter blades, etc. Operation both simple and efficient. Is a valuable economy. Have made charging sticks by machine before the war.

13. Crushers:

Buntjes Consolidated Mines, Limited.—Carried out an economical repair job on a 30 in.×12 in. Hadfield crusher. The engineer made a pair of case-hardened toggles from cam shaft at a cost for labour of £3 5s., which allows an ample margin for power costs, etc., compared with the imported price of £9 10s.

From similar material a wedge block toggle seat for 30 in.×12 in. Hadfield crusher has been made.

Ferreira Deep, Limited.—F. & C. or Hadfield's 10 in.×20 in. and 12 in.×30 in. All toggles when worn badly reformed cost of 8s. each. Broken toggle blocks replated by M.S. ones made on mine, also back wedges for fixed jaw faces.

East Rand Proprietary Mines, Limited.—Have made wedge blocks and toggle seats from this material. Making crusher parts from old cam shafts or suitable scrap valuable economy.

14. Drill Steel:

There is great activity in the collection of old drill steel from surface and underground workings, and the quantity forthcoming is remarkable. All this odd steel is welded up and the economy effected is reflected in the greatly diminished call for new steel.

The Village Main Reef Gold Mining Company, Limited.—Have done very good work in making drill steel from scrap.

Witwatersrand Deep, Limited.—Method of faggoting up odd bits of steel to make drills is, I believe, novel and certainly excellent.

Ferreira Deep, Limited.—Has done well with scarfing and finishing tools.

City and Suburban Gold Mining and Estate Company, Limited.—Has been welding old hand steel and hollow steel in Tregaskis furnace with good result.

15. Welding Steel:

Considerable variation in practice obtains on the mines in regard to welding. Some smiths adopt scarfing in varying degrees, others lap welding, others again are trying the butt weld.

Buntjes Consolidated Mines, Limited.—Scarf and weld all machine and hand-drill steel. Hand-drill steel welded under rock-drill hammer. Machine-drill steel welded under steam hammer.

16. Welding Drill Steel:

The Ferreira Deep, Limited, has devised the method of scarfing steel in Leyner sharpener. By this method it is stated one man can scarf 2,000 pieces per shift as against about 200 using the anvil. The welding up is done under a rock drill hammer, the anvil having a V groove to keep steel in place. It is believed that 300 welds of solid steel can be done per shift.

There is the Holman machine for removing any burr on hand-drills after sharpening. When the drill is thrust against dollie, air is automatically turned on into operating cylinder.

17. Welding Hollow Steel:

Several methods are in vogue for welding hollow steel. It is difficult to say which is the best. The six point dollie for scarfing is perhaps that most likely to secure a strong weld.

East Rand Proprietary Mines, Limited.—Weld hollow steel and use scarf weld for "Leyner" steel and Basket welding for "Hydromax," "Atlas" and other similar machine steel. Best type of weld is matter of opinion.

18. Making Drill Steel :

The Village Main Reef Gold Mining Company, Limited, have been very successful with $\frac{7}{8}$ in. hand steel made from shoe shanks. The shank is punched out of the shoe, heated and drawn out under hammer. One smith can make from 200 lb. to 210 lb. of steel per shift, costing 3d. per lb. and about 2 tons of this steel is used per month on the Village Main Reef.

In tempering only $\frac{1}{8}$ in. to $\frac{1}{4}$ in. of the drill tip is put into water which is kept at about 200°. Mine water was found to affect tempering, and water for this purpose is collected from steam traps.

The appearance of this steel makes it easy to sort out from steel requiring different tempering.

City Deep, Limited, have made drill steel from wire rope, giving the cost at 3d. per lb. At date this has not been extensively used on the mine, and further results are awaited.

Ferreira Deep, Limited, have made $\frac{7}{8}$ in. drill steel from old grizzley bars, at a cost of about 2d. per lb. It is stated that this steel tempers very well.

Witwatersrand Deep, Limited, is making drills by faggoting odd bits of drill steel from 3 in. to 6 in. long.

19. Shanking Jack Hammer Steel :

City and Suburban Gold Mining and Estate Company, Limited, have devised an excellent machine for shanking hollow Jack hammer steel. This consists of a spindle on which are mounted two 12 in. diameter hardened steel cutters, kept apart by a distance piece, and having teeth cut on the inner faces with a bull-nosed chisel. The discs revolve at 1,000 to 1,500 revolutions per minute, and the steel to be squared is heated and thrust between them. The width of distance piece between discs determines the size of square cut on steel, and the diameter of the distance piece relative to 12 in. cutters, determines the length of square, the distance piece forming a stop for the steel. Two men and four natives with use of furnace, hot mill and Leyner sharpener do 200 shanks in eight hours. Cost per shank, about 5d.

Rose Deep, Limited.– Suggestion is new one, but our present system of jumping these shanks appears to be much more economical.

East Rand Proprietary Mines, Limited.—End is heated and punch put in the hole. End drawn up to gauge under hammer, dressed and tempered. For Leyner drill steel have a machine. Any successful method of shanking by machine better than drawing down under hammer.

20. Shanking 1 in. Hexagon Steel :

Langlaagte Deep has a good method of shanking 1 in. hollow hexagon steel, which unless squared is apt to slip round in the rock drill chuck. The steel is jumped up inside a jig to $1\frac{1}{8}$ in. diameter and then squared to $1\frac{1}{16}$ in. in the Leyner sharpener. While squaring air and water are blown through the steel which prevents the hole in steel closing up.

East Rand Proprietary Mines, Limited.—For 1 in. steel practice to jump or stave up the end. End then drawn down to gauge and finished off similar to Jack hammer. Any successful method of shanking by machine superior to drawing down under hammer.

21. Flanges :

Excellent flanges drop-forged in one heat are being made by the *Wolhuter Gold Mines, Limited*, of scrap plate, in all sizes up to 12 in. bore. The heated plate of the required flange diameter, with the hole in centre proportioned to the depth of flange collar required, for screwing or rivetting, is placed on a die and dollie driven into the centre under hammer.

22. Furnaces :

The necessity for a good soaking heat in working up scrap led to the engineer of the *City and Suburban Gold Mining and Estate Company, Limited*, designing a furnace. Apart from its utility in the work of renewing such things as battery parts and truck wheels, the engineer finds it pays him, with this furnace, to faggot up scrap and make flat iron.

The pre-war price for flat iron ranged about 14s. per 100 lb.; to-day's price is 62s.; the City and Suburban Gold Mining and Estate Company, Limited, costs are 25s. per 100 lb. for odd lots specially made, and 16s. for a whole shift output at piece work rates. With this furnace $1\frac{1}{2}$ in. copper bars for electrical purposes are run out of scrap.

Two days' run on faggoted scrap gave cost as 8s. a cwt.; for 3 to 4 in. blooms weighing 100 - 160 lb. Scrap charged at 1s. 6d. a cwt. and use of hammer 32s. for two days. This furnace has been adopted on many mines with beneficial results. It is undoubtedly of great use wherever there is a large hammer.

23. Rock Drill Parts :

1. Rock drill parts are extensively made on the mines, resulting in considerable economy as instanced by a statement from *Nourse Mines, Limited*. A recent lot of rock drill parts made on that property would have cost to buy £148 15s.

Making this lot, using two-thirds scrap and one-third new material (taken at current prices) with labour, tools and power, cost £54 1s. 7d.

Several mines are stamping swivels and crowns out of odd scrap. At *Ferreira Deep, Limited*, it is stated that one smith can make 70 to 80 of them per shift, so that the cost cannot be more than 2s. or 3s. *Consolidated Main Reef Mines and Estate, Limited*, state with new material at present prices, the cost to be 6s. each

The market price to-day is 13s. 6d. each.

These mine-made fittings stand up to the work equally as well as the imported parts, and their manufacture is particularly creditable seeing that numerous jigs and methods have first to be thought out.

Bantjes Consolidated Mines, Limited, find making own "U" bolts great saving.

Durban Roodepoort Deep, Limited.—Can be made to certain extent, but doubtful if as good as imported. Made chuck keys in white iron at 1s. each. Drop forged ones cost 5s. 6d. each, and answer very well.

Goldenhuis Deep, Limited.—Rock drill parts made for years, for instance, air chests cost about £9 each. When worn out re-bore and screw them and make two plugs to suit at cost of 12s. each. Air chests then as good as new.

East Rand Proprietary Mines, Limited.—Made from old scrap, *i.e.*, rails, grizzleys, broken pistons, etc. Following list of articles mine makes (d.f. = drop forging) :—

Side rods, arm and clamp bolts, crossheads (d.f.), spanners (d.f.), cradle liners, cradle pillar tubes, chuck wedges (d.f.), chuck bushings (d.f.), rotching handles, stoping bar nut, air lap handles (d.f.), feed screen supports, valves,

valve stoppers, valve plates, tappets (d.f.), cylinder bushings, ratchet springs.

Ratchet springs made from new piano wire at 2d. each. Makers price 8d. each. Have surplus of crowns and swivels due to reducing number of reciprocating machines. Making rock drill parts valuable economy. Made parts before and since the war.

City and Suburban Gold Mining and Estate Company, Limited.—Made crown, swivels and lacking screws before the war, but machine tools have been too busy since.

City Deep, Limited.—In use before the war (spares, crossheads, "U" bolts, spanners, etc.).

Consolidated Main Reef Mines and Estate, Limited.—Swivels and crowns made of broken stem-ends at cost of 6s. each (against 13s. 6d. imported). Equally good. New idea.

Crown Mines, Limited.—Considerable quantity made on mine, resulting in great economy.

Robinson Gold Mining Company, Limited.—Make lot of hammers for B.C.[21] rock drills from old stem pieces. Life three to five months. Better than imported.

II. *Utilising worn out pistons of the larger sizes of Rock Drills for the smaller sizes of Drills.*—

A scheme recently introduced by engineer of the *Village Deep, Limited*, is effecting a considerable saving as regards rock drills on this mine.

The old pistons of the 3¼ in. Ingersoll machines are swaged down sufficiently to allow of the old spring recesses being turned off, and by closing the hole, it allows of boring and screwing to fit the standard rifle nut. The piston is then turned to 2⅞ in. diameter and used with the 2¾ in. Holman machine. Just at the present time the largest sized pistons for these machines are not obtainable here, so by this use of the discarded pistons from the large machines, the life of the cylinders of the smaller machines can be extended in the usual way, as also can the front head bushing, since the rod of the 3¼ in. machine is larger in diameter than that of the 2¾ in. machine.

Most of the mines have a number of these discarded pistons, and in many cases it is true that these are being used for other purposes but if they could be adopted for the smaller machines an appreciable saving in rock drill spares would be effected.

The present day cost of a piston for a 2¾ in. machine is £7 11s. 9d., and the front head bushings 15s., as against the cost of 14s. for swaging down, turning piston and rod, boring front head lines, besides the further life of the cylinder which costs £8 1s. 8d.

24. Foundry :

The engineer of the *Robinson Gold Mining Company, Limited*, supplied some interesting figures regarding the foundry that has been run on that property for the last 28 years.

For the twelve months ended October last, the output of iron castings was 66 tons, worth £1,930 at current rates and 7·4 tons of brass castings, worth £1,857, that is castings to the value at current rates of £3,787 were made on the mine instead of being bought. Excluding the value of scrap used, the cost of producing these castings was approximately £1,500 including a certain quantity of new pig iron, coke, and wages of workmen, seven in number, namely, one pattern maker, two moulders, one apprentice and three natives.

Apart from the direct saving in making castings on the mine, the value of the time saved in repairing break-downs must be very considerable.

East Rand Proprietary Mines, Limited.—Brass work large factor. Have brass foundry and do all own castings in brass, aluminium, gun and acid resisting metal, which includes large spares for Sulzer underground pumps. Castings amount to 4 tons per month. Since the war have made white metals for own use, totalling 53,000 lb. Castings, white metal and solders resulted in large savings. Make own solder.

If work sufficient and continuous, foundry is useful and economical asset, and more so for emergency work.

25. Rock Drill Steady :

"Nettle's Patent Rock Drill Steady," devised at the *Ferreira Deep*, is an attachment for a hammer drill to keep steel in place when collaring a hole. When one considers the difficulty of collaring a hole with a hammer drill, and the damage to steel in the process, the idea strikes one as being a good money saver.

This attachment is being tried on many mines.

26. Jenkin's Detachable Bit :

Jenkin's *City Deep* "Detachable Bit," better described perhaps as "jointed steel." A substantial joint in the drill at about 18 in. from point enables one shank to be used for many drills. To equip our Ingersoll machine in the ordinary way, 40 drills are required, having a total length of 214 ft. and weighing 917 lb.

With Mr. Jenkin's method, 40 drills are required having a total length of 70 ft. and four shanks of a total length of 15 ft., drills and shanks weighing together only 347 lb. Sharpening the ordinary drills involves handling about 900 lb. of steel as against only about 300 lb. with Mr. Jenkin's process.

Compared with the ordinary equipment of a drill Mr. Jenkin's method introduces two important economies :—

(1) The steel required for a new machine is reduced by 62%, or, say, two-thirds.

(2) The weight of steel to be taken in and out the mine every day is reduced by 68%, just over two-thirds.

These possible economies are sufficient to warrant the method being given a thorough trial on other mines.

Mr. Pryce's report, dated the 25th September, 1917, dealing with a test of this jointed steel over a period of 15 months, indicates that the miners prefer this jointed steel to the old type.

Crown Mines, Limited.—Has cheapened the making of these drills by new method. The sockets are made entirely on the Leyner sharpener at the rate of 40 per hour.

The inside of socket is formed in three heats with a first, second and finishing dollie, this last dollie giving the socket the exact taper and depth required. The socket is then given a fourth heat, plugged, and finished off in a former on the outside. They are stronger than those having sockets first bored out by lathe. The improvement of *Crown Mines'* method very marked.

27. End Liners for Tube Mills :

It has become a general practice to make tube mill end liners from old shoe shanks or grizzley bars.

Ferreira Deep, Limited.—State two men will make two complete end liners in three days.

City and Suburban Gold Mining and Estate Company, Limited. Give cost of liners for one end at £3 5s. 6d.

City Deep, Limited. Old dies are used as tube mill ends, which give about 9½ in. end at a cost of 30s. for installation. This end has been running for over 12 months.

The Village Main Reef Gold Mining Company, Limited.—Custom here to build in shoe shanks without dressing; cheap and efficient.

Oxy-Acetylene Welding:

This process is in use on several mines for welding up broken castings, cutting up girders and plates, etc., and it appears to me that the system could be adopted with advantage on other mines. An apparatus with a capacity for welding up to 2 in. and cutting plates 6 in. thick costs £120.

Bantjes Consolidated Mines, Limited.—Sirius plant imported and installed in 1912. Use has been enormous and small capital outlay been saved many times over.

29. Plates:

The engineer of the *Geldenhuis Deep, Limited*, uses a steel railway sleeper flattened out, which makes a good plate, 6 ft×13 in., at a cost for labour of 1s. 6d. These plates are used for lining bins, repairing truck bodies, etc.

Ferreira Deep, Limited.—Find them excellent for foot wall chutes. The construction of chutes is worth noting, the timbers being wedged together so as to be readily changed.

A good deal of plate for lining bins, repairing truck bodies, idler ends and other purposes is obtained from odd bits of pipe flattened out.

31. Rails and Crossings:

Several mines are making switches and crossings. In December, 1916, the *Modderfontein "B" Gold Mines* obtained quotation for 30 in. gauge crossing, 15 ft. long of 30 lb. rail. The price quoted was £14 15s. To-day these crossings are made on this mine at a cost of £9 15s. with piece work labour at 27s. 6d. per crossing and material at current prices. *Nourse Mines, Limited*, gives cost of 12 ft. switch of 30 lb. rails at £9 3s., using sleepers of old bin lining costing 1s. 6d. as against market price 2s. 7d.

32. Idlers:

I.—*Rope Idlers.*—

City and Suburban are making rope idlers. The centre for rope is an 8 in. diameter cast iron collar costing 4s. 3d., and the ends of plate stamped out from scrap in a die. The roller turns on 1¼ in. steel shaft pinned in bracket at each end. A recess around spindle in centre is filled with C.C. motor oil, which is found to last the life of the C.I. centre. The cost is £1 17s. 6d. complete. The cost of replacing a worn C.I. centre is about 6s. 6d.

II.—*Conveyor Belt Idlers.*—

Knight Central make from short length of 4 in. pipe fixed to 1 in. shaft, and run in ordinary bearing.

33. Springs for Leyner Sharpener:

East Rand Proprietary Mines, Limited, have made springs for Leyner drill sharpener from rope, at a cost of 2s. to replace those bought at 6s. 6d. each.

Many of the mines are now making these.

East Rand Proprietary Mines, Limited, made out of old wire rope, and have proved satisfactory. Cost is 5d. compared with purchase price 5s. 11d., which is valuable economy. Average life of springs made here is fourteen days as against three days life of original spring.

34. Metallic Packing:

The Knight Central has a process for making the metallic packing fit some engines.

As the material costs only about 10s., it is obviously cheaper to make the packing than pay the market price of £4 per 1 in. diameter of rod, say, £16 for 4 in. piston rod packing.

East Rand Proprietary Mines, Limited.—Cast and machine all own metallic packing, and adopt it wherever possible. Made 1,300 lb. since war. Is a valuable economy. Metallic packing as adopted on first class locos. is the best. Great success under unfavourable conditions such as sand storms and irregular supervision.

35. Trucks:

In response to a demand for something that would not break, the foreman smith at *Consolidated Main Reef Mines and Estate, Limited*, got out a truck frame of Jarrah 4 in. thick, bolted up with scrap plating, at a cost for labour of 22s. It certainly looks a strong job. *The Ferreira Deep, Limited*, also are making truck frames of Jarrah.

The cost of labour is stated to be 25s.

Crown Mines, Limited, are trying wooden truck frames as used at *Roodepoort United*; also old frames re-inforced with wood. Latter idea may be cheaper.

36. Truck Axles:

Satisfactory truck axles are being made of wire rope welded up and other scrap material.

Durban Roodepoort Deep, Limited, made on mine from broken stem ends welding up two old axles to make one new, small pieces of cam shafts or any old shafting. Made some more as an experiment from old wire rope welded together.

East Rand Proprietary Mines, Limited.—Welding up wire ropes is new. Our practice to weld wedge pieces into end, thereby renewing them, and is valuable economy, as body of axle is saved. Have practiced this since war began.

City and Suburban Gold Mining and Estate Company, Limited.—Welding up scrap in furnace for truck axles with good results.

37. Truck Trunnions:

Truck trunnions are being made from scrap at a price that indicates a saving.

East Rand Proprietary Mines, Limited.—Drop forged from scrap. Valuable economy. Practiced since war.

City and Suburban Gold Mining and Estate Company, Limited.—Made them in dies out of scrap for seven years.

38. Truck Wheels:

Truck wheels are mostly discarded through flanges wearing out. Several mines are shrinking on steel flanges at a cost stated to be 4s. This is perhaps a low figure, seeing that the old flange has to be turned off and a ring turned up and shrunk on.

The City and Suburban re-flange old wheels by placing a hot wheel in a die under the hammer and bringing up a new flange out of the metal of the wheel. This method slightly reduces the width of the tread, but makes a good job. The cost is given at 2s. 6d. per pair.

39. Sanitary Buckets:

Imported sanitary buckets being no longer procurable, several mines have met a shortage by making them. It appears that a bucket of 18 in. gauge

that galvanised iron can be made at a cost of about 15s. exclusive of lid.

The New Modderfontein Gold Mining Company are making sanitary buckets costing approximately 20s. This pattern is now being largely used on other mines.

10. Tools :

Most of the mines are making tools of a variety that would stock an ironmonger's shop, comprising every description of blacksmiths' swages, hammers, zinc lathe tools, ordinary lathe tools, chisels, spanners, pipe wrenches, etc., etc. An important item is dies, dollies, and formers for drill sharpening machines. The comparative costs of making and buying are stated by Mr. Ritchie to be, on the *Nourse Mines* :

2 dies, to make, £2 13s. ; pre-war price, £3 10s.
1 dollie, to make, 17s. ; pre-war price, £2.
2 formers, to make, £1 10s. ; pre-war price, £7 10s.

Excellent 4 lb. and 14 lb. hammers are being turned out at a cost of about 4d. per pound from shoe shanks, and other scrap material comparing favourably with imported hammers at 6d. per lb. (price, December, 1916).

Bantjes Consolidated Mines state that one smith and two natives can make 25 4 lb. hammers per day, indicating a labour cost of 2½d. per hammer.

City and Suburban state inclusive cost of 4 lb. hammer to be 8½d. and 14 lb. hammer at 3s. 3d.

The City Deep make a very serviceable pipe wrench from old grizzley bars.

Bantjes Consolidated Mines, Limited.—Number of all descriptions made, particularly dies and dollies for drill sharpening machine (Leyner) which cost less than present market price.

Durban Roodepoort Deep, Limited.—Smith's tools, drifts, etc., have been made past eighteen months from old 1¼ in. rope, and anything up to 2 in. round can be made from this material. Cost of 4 lb. hammer seems low.

Nourse Mines, Limited.—Stilson wrenches are being reclaimed, and by the introduction of new jaws and springs turned out as good as new.

East Rand Proprietary Mines, Limited.—Two men constantly employed keeping workshop tools in order and making tools at present unobtainable. Also make dies, dollies, etc., for Leyner drill sharpener. No new hammers made. Old hammers dressed and faced. Decided economy on work done in pre-war days. Cast steel tools made of old shoes. Timbering chisels made out of hand and machine drill steel.

City and Suburban Gold Mining and Estate Company, Limited, have made most of dies, dollies and formers ourselves, since we had sharpening machines. During last eighteen months have made zinc-cutting tools from old shoe-shanks. Some 6,000 4 lb. hammers made from old shoe shanks.

City Deep, Limited.—Wire rope handles used in 14 lb. hammers for mine use.

Consolidated Main Reef Mines and Estate, Limited.—Smith tools always made. Dollies for Leyner's all made on mine. No new hammers made, but old ones re-dressed.

12. Waste :

One of the mines has for some time been using old hemp ropes, teased out, as a substitute for waste.

Some of the mines are cleaning waste, but the recovered waste has little value. It has been suggested that sweat cloths are more economical than waste, being more easily recovered and cleaned.

13. Steel Belt Fastener :

Knight Central, Limited, suggest using these a second time by burning out old belt and straightening out fastener. This can easily be done by a native.

17. Pump Details :

R.D. Pump.—Repaired worn part of pump shaft. Shaft worn usually at the gland is turned, tinned and run with brass in a mould. Then the brass section is turned in the lathe, and saves scraping the shaft. Tried in brass and white metal. No results available, being experimental stage.

Experimental Plunger Casing.—Suggest use of granite casing for plunger which being impervious to water with a high polish should reduce friction, and not likely to groove owing to hard skin.

Worthington Pump.—Bantjes Consolidated Mines suggest lead ring substitutes in place of red fibre joints as supplied by makers for 4½ in.×10 in. Worthington pumps. The valve covers on these pumps have to be removed frequently to examine valves and seats, and make renewals when necessary. Red fibre makes a good joint so long as it is not disturbed, but with repeated removals of cover they soon collapse. They are expensive to produce as the fibre is bought in the sheet (¼ in. thick), cut up into suitable squares by band saw and then sent to lathe to be turned up on the outside and through hole bored from solid. Lead rings make quite as good joints for these particular pumps (or anywhere where a recess can be provided for joint). The advantage of this is that when the joint is discarded the old ones are brought back to shops and melted up and re-run into jig. An apprentice can comfortably run up 300 joints in one shift—red fibre 50 for a shift.

When melted lead has been run in recess "C" in jig, the whole jig is lifted by handle and dropped on a block of wood. The bottom of solid mandril "A" strikes the wood first which causes "A" to rise, leaving the lead ring still resting on mandril "B" as the jig still descends mandril "B" then gets the blow which causes lead ring to be knocked out of mould.

Sulzer Pumps. — Durban Roodepoort Deep, Limited, have adopted a front packing bush of white metal which runs well and reduces the danger of seizing when pumping dirty water.

The bushing, when worn, can be readily melted and run up again in a cast iron mould.

49. Quasi-Arc Welding :

Crown Mines, Limited, report many big jobs satisfactorily repaired, most useful in building up badly worn shafts, in journals or shafts of winding engines on which the coupling of main spur-wheel has become slack.

[Extracts from Report made by Mr. W. Eldsdon Dew, Acting Consulting Electrical and Mechanical Engineer to the Central Mining and Investment Corporation, Ltd., August 28, 1918.]

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Determination of Copper Minerals in Partly Oxidised Ores.—"It is important in ore flotation to be able to distinguish between copper present as

sulphide and oxide minerals. Extraction by 5% cold sulphuric acid does not effect a quantitative separation of oxidised compounds. Metallic iron from the crushing machinery is dissolved and causes deposition of metallic copper. Only one-half of the copper in cuprite passes into solution, while some chalcopyrite, bornite, and chalcocite are also dissolved. Neither does a 5% solution of ammonia give satisfactory results. The sulphides are dissolved to a slight extent, while the formation of gelatinous silica interferes with the solution of oxidised minerals. These are also defects of Hunt and Thurston's method (Colorado School of Mines, May, 1917, 7, 157) based on the extraction of the oxidised minerals with alkaline sodium tartrate and alkaline ammonium sulphate. Extraction with dilute sulphurous acid is considered to give the most correct results: 2 gm. of ore, pulped to pass a 100 or 150 mesh sieve, is shaken with a solution containing 3% of SO_2 for one-half to two hours. The insoluble residue is filtered off and washed with dilute sulphurous acid, and the filtrate then contains all the copper present as oxide, carbonate, or silicate in the ore. After acidification with nitric acid the copper can be estimated electrolytically. Sulphide minerals are not affected. Metallic iron—up to 3%—is rapidly dissolved and has no influence if excess of sulphurous acid is present. No interference is caused by the formation of gelatinous silica and ores of any grade can be dealt with. Metallic copper must be determined separately."—C. E. Van Barneveld and E. S. Leaver, *U.S. Bureau of Mines: Eng. and Min. J.*, 1918, *105*, 552-555.—*Journal of the Society of Chemical Industry*, May 31, 1918, p. 270A. (A. W.)

Method of Sulphur Analysis in Ores.—"A method is described for estimating sulphur gravimetrically in ores and furnace products by oxidation to sulphate and precipitation as barium sulphate, which avoids the difficulties usually experienced in oxidising mattes and calcines, or ores containing much copper or zinc sulphide. 0·5—1·0 gm. of the sample is treated with 10 cc. of a 20% solution of sodium chlorate, and 7—15 drops of a mixture of equal parts of bromine and glacial acetic acid. 10 cc. of nitric acid nearly saturated with potassium chlorate is then added and the mixture agitated. After two or three minutes the sulphur is oxidised, and the mixture is then evaporated to dryness. The residue is cooled, 5 cc. of 60% hydrochloric acid added, and after heating till all soluble substances are dissolved, the solution is diluted to 150 cc. and neutralised with ammonia. If lead is present, about 1 gm. of ammonium carbonate is also added, the mixture boiled for one minute, filtered, and the precipitate washed thoroughly. The filtrate is heated to exp. ammonia, hydrochloric acid added in excess, and then about 15 cc. of a 10% solution of barium chloride. The mixture is boiled for 10 minutes, allowed to settle, filtered, and the barium sulphate ignited and weighed. This method avoids the formation of globules of free sulphur during the oxidation by preventing heating of the solution. Potassium chlorate may be used instead of the sodium salt and is more stable in nitric acid, but much less soluble in water."—F. G. Hawley, *Eng. and Min. J.*, 1918, *105*, 385-386.—*Journal of the Society of Chemical Industry*, May 31, 1918, p. 270A. (A. W.)

METALLURGY.

Sodium v. Potassium Cyanide.—For titrating potassium cyanide it has been the universal custom to make up a solution containing 1·303 silver nitrate, so that 1 cc. was equivalent to 10 mgm. KCN. This was roughly 0·0767 *N*. For titrating commercial sodium cyanide it is possible, by a convenient coincidence, to use *N*/10 or *N*/20 silver solution without necessitating any calculation. One cc. of *N*/10 silver solution is equivalent (by Liebig's titration, or using the preferable modification with potassium iodide indicator) to 5·202 mgm. of CN, or to exactly 9·802 mgm. of NaCN. Now, 98 is almost the exact percentage of actual NaCN in the high grade commercial material now in use. Therefore one can titrate solutions with *N*/10 silver nitrate and call 1 cc. equivalent to 10 mgm. of the actual 98% salt which has to be weighed out in making up the solutions. For technical purposes it is perhaps perferable to use *N*/20 solution (1 cc. = 5 mgm. commercial NaCN), as the end-point with iodide indicator is delicate and the burette readings then also indicate 'pounds per ton of solution' directly. For instance, taking a 10 cc. sample: suppose 2 cc. of *N*/20 silver nitrate are consumed; this indicates 10 mgm. or 0·10% of commercial sodium cyanide in solution, or 2 lb. per ton of solution—the 'ton' or 'fluid ton' used in hydrometallurgy being about 32 cub. ft., or the volume of 2,000 lb. of water.

When determining sodium and potassium in a mixed cyanide, chlorides and carbonates being the usual impurities, it is often possible to work by directly evaporating with hydrochloric acid, gently igniting and weighing the mixed chlorides remaining, and titrating chlorine in part of the residue. The following formula, based on 1914 atomic weights, gives the results in the most direct manner possible:

If A is grams mixed chlorides, and B is total grams chlorine in mixed chlorides; then K in grams is 2·4286 A minus 4·004 B, and Na in grams is 3·004 B minus 1·4286 A or A minus B minus K.

Not infrequently the class of cyanide can be determined simply by titrating cyanogen and alkalinity in a fresh solution, using methyl orange as indicator.

It may not be out of place to call attention to the importance, when testing cyanides for the presence of alkaline sulphide, of preparing the solution at the moment of making the test, or, what is better, of dissolving the solid cyanide in the reagent to be applied. If the cyanide is dissolved in water and allowed to stand even a few minutes, the sulphide content may be seriously diminished, and traces of sulphide may be easily overlooked. Three simple methods are available: Shaking with fine lead carbonate suspended in water; dissolving the solid cyanide in a solution of silver nitrate containing slightly less than 1 molecule $AgNO_3$ for two equivalents CN, or dissolving the solid cyanide in a little mercuric chloride solution, each of these reagents yielding a black precipitate or dark coloration. The sulphide may be quantitatively determined by the silver or mercury method. Incidentally, while sodium cyanide is not deliquescent, it is decidedly more soluble in water than potassium cyanide.

In dilute solutions there is no apparent difference in the stability of sodium as compared with potassium cyanide; in each case decomposition is greatly increased by access of air and retarded by presence

of the alkali. Prolonged tests made over a period of three years indicated that in strong solutions there is comparatively little difference in stability, the advantage, if any, lying on the side of the sodium compound, which in the test lost about 40% of its cyanogen in 38 months, against nearly 50% lost by commercial potassium cyanide.

It has long been stated that 5 gr. of cyanide have repeatedly proved fatal, at which rate a pound would suffice to kill about 1,400 persons. This statement no doubt refers to cyanide of the old type, containing probably 30% to 35% of potassium cyanide or, say, 12% to 14% of cyanogen. Modern sodium cyanide—commercial as well as 'C. P.'—contains 50% to 52% cyanogen, or practically four times as much as the material formerly sold, and is presumably four times as lethal in its action, so that, as a measure of its toxic effect, a pound would contain more than 5,000 fatal doses."—W. J. Sharwood.—*Engineering and Mining Journal*, May 18, 1918, p. 918. (H. A. W.)

Abstracts of Patent Applications.

568.18. J. S. Ross (1), G. L. Crump (2). Improvements in the extraction of copper and other metals or compounds thereof, from ores and the like containing them. 2.7.18.

This application is for a process of leaching unbrushed copper ores with sulphuric acid, on the assumption that the disintegrating effect of the solvent will render crushing unnecessary.

763.18. Andrew F. Crosse. Improved process for the production of phosphates from certain phosphatic rocks. 12.9.18.

This application is for an improved process of converting insoluble iron and alumina phosphates into citric soluble phosphate, and thereby rendering the phosphate of special use as a fertiliser.

The process consists of mixing the ground rock phosphate with caustic soda and lime, then treating the dry mixture to a temperature between 200° to 250° C.; then cooling; then agitating in hot water, adding more lime to precipitate the phosphate as calcic phosphate and regenerate the caustic soda for reuse. The resultant product is allowed to settle, the regenerated caustic soda solution is decanted off and the settled solid is dried and is ready for use. The principal improving feature of this process is the formation of only a small proportion of aluminate of soda, thereby overcoming loss of soda, and the difficulties of settlement and subsequent separation of the regenerated caustic soda from the solids, formerly experienced.

590.18. Oliver Reece. Improved process of treating ore concentrate, fine, slime, dust and the like. 25.9.18.

This application relates to the treatment of concentrate, fine, slime, precipitate, dust and like material produced in mines and smelting plants or other ore reduction works.

Its first objective is the reduction of losses arising from roasting, sintering, calcining or some similar process, in the carrying out of which losses are known to occur.

It consists of treating the materials in question with a binding and fluxing agent, which cements the particles together and the moulding of the mixture into briquettes.

722.17. H. C. Hilton (1), J. J. R. Smythe (2), W. Alderson (3). Improvements in means or devices for use in the ventilation of mines. 19.11.17.

This application appertains to a means, device or arrangement which can be utilized for moving or transferring large volumes of air from a purer source of supply to badly ventilated parts or places.

The application aims at constructing a means, device or arrangement by which a comparatively small jet of compressed air can be utilized to induce a much larger volume of air by a series of successive steps or stages, and to convey and deliver such relatively large volume of air through a pipe line or along any other suitable conduit from the point or points of induction to any desired point or points where it is or may be required to introduce air for the purpose of ventilation.

763.17. John William Birtley Craggs. Improvements in warning the driver in the event of a mine skip or cage becoming derailed, or disengaging its guides, and for operating and controlling the trip gear of the engine or motor. 7.12.17.

This application deals with means for giving warning in the event of a mine skip or cage becoming derailed or disengaging its guides, and operates by means of the derailed skip or cage coming into contact with a bare copper wire strung on insulated supports in close proximity to the track. On contact being made between the skip and the said wire a circuit is completed through the track or winding rope, *i.e.*, through earth, which causes a bell to ring or a visual alarm to signal the fact to the driver.

The claims are five in number, and comprise :—

1. Means for giving warning of a mine skip or cage becoming derailed or disengaging its guides as above.

2. The use of a relay magnet introduced into the circuit for opening the low voltage trip of an electric hoist, or for operating any overwinding or controlling device of a steam winder.

3. An arrangement for signalling from the skip or cage to the driver by means of the said bare wires.

4. The employment of insulator brackets for supporting the bare wires, and an arrangement of tension screws for straining the wires.

5. A general claim for the first two claims combined in connection with the corresponding drawings, and substantially as described and illustrated thereby.

Changes of Address.

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APR 2. 5 1920

THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA.

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Vol. XIX. JANUARY 1919. No. 7.

APPLICATION OF THE THEORY OF PROBABILITY IN THE DETERMINATION OF ORE RESERVES.

By G. A. Watermeyer (Member of Council).

Great credit is due to Mr. A. E. Hooper,* Surveyor to the Aurora West United G.M. Co., Ltd., for, in the first instance, recognising the importance of accumulating data on the frequency of occurrence of various values in his mine. This has been of considerable assistance in the later development.

It has been the custom in the past to determine Ore Reserve by the individual valuation of each block of ore based on samples taken at uniform intervals, or otherwise, on the perimeter of the block where accessible. These samples are assayed and the results recorded in the first instance on the sample sheets, which show the sections graphically on a large scale, and later on the assay plans, which show the result of each section on a much smaller scale, but represent their position in the mine. The samples are meaned together over arbitrary distances, say, 50 ft. in drives and rises, and the mean of samples taken along stope faces are done separately. In order to arrive at the mean for the block, these results are weighted according to the lengths over which they were taken. In estimating the value of the ore stoped each month a similar procedure is adopted. The results obtained from the mill have shown that this method of obtaining a mean value is uniformly in excess of the mill return. If the percentage in excess were a constant it would be a simple matter to determine the constant and apply it to future determinations so as to predict the mill return. Experience, however, has shown that this is not a constant and varies very considerably from month to month. In order to get over this difficulty various methods of adjustment have been put forward at different times. One method consists in meaning the sections, reducing all values above the mean to the mean and then remeaning. A second arrived at a result by taking the mean between the first and second means. A third consists in reducing each section above 1,000 inch-dwts. in value to 1,000 inch-dwts. and then meaning.

Denny, in his paper on "Rand Economics," read before the S.A. Institution of Engineers in April, 1917, mentions what he calls the method of variable co-efficients, and puts up a very pretty theory of values penetrating to various depths from the point sampled. The idea of variable co-efficients in the author's opinion, is a sound one, but he will endeavour in this paper to develop it on a logical hypothesis.

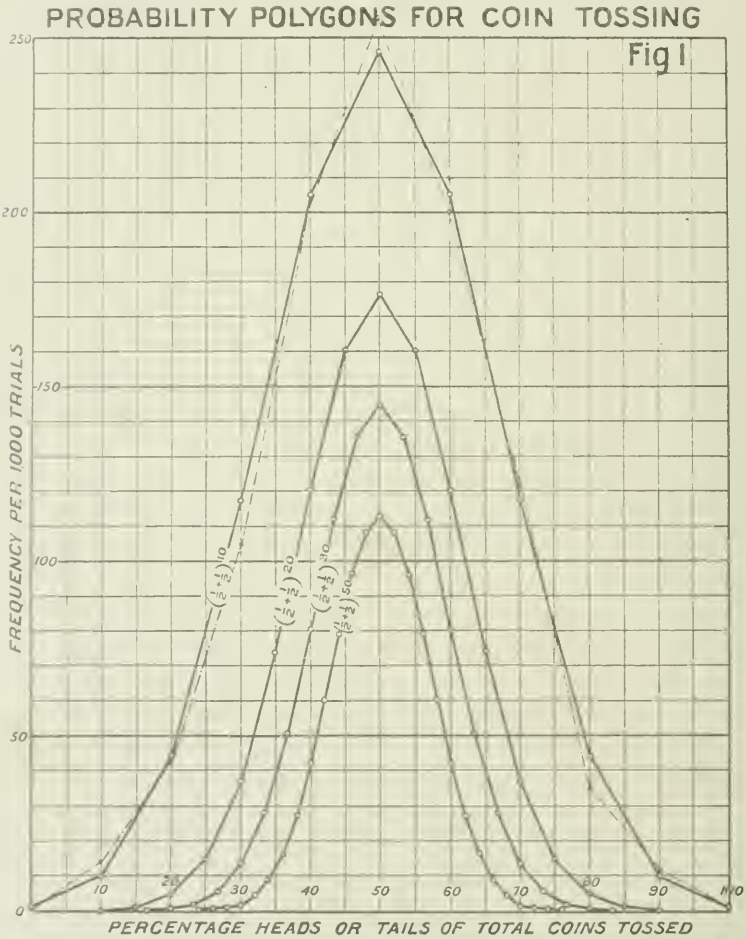
The objects of these different methods of adjustment are identical, namely, to arrive at a prediction of resulting value which will come within reasonable limits of the mill results. Numerous samples are taken on each reef in each mine every day for the purpose of making these predictions. The results of the predictions, all will agree, are not commensurate with the time and money spent on the sampling and assaying. Experience has shown that predictions determined on the arithmetic mean of the samples are invariably in excess of the mill return. One is led to the conclusion that the arithmetic mean of the sampling results is not

* Mr. Hooper contributes a few historical notes on the subject on page 107.

the most probable mean. We shall have to go further and see whether there is not some law governing the distribution of values which will enable us to arrive at a much closer valuation than has heretofore been possible.

In all investigations in the domain of physical science, if a series of observations are made for determining the value of one or more unknown quantities, and these observations give discordant results, it is of the utmost importance to solve the problem of determining the most probable value of the unknown quantities. Each observation is a measure and subject to error, however carefully it may have been made. Errors may be constant and regular or accidental and irregular. Constant and regular errors may be investigated, and when their causes are understood, eliminated. Accidental and irregular errors have irregular causes, and their effects are governed by no fixed law. The problem to be dealt with is to combine them so that unavoidable irregular errors may have the least effect on the results. For this purpose the method of least squares is used to restrict the effect of irregular errors within the narrowest limits according to the Theory of Probabilities, and determine from the observations themselves the errors to which the results are probably liable.

I am indebted to Drs. J. M. Troup and G. D. Maynard* for much of the following: The collection of facts and their systematic study is, and always must be, the foundation of every science. By observing the frequency with which one event is associated with another, one is able to judge the



* See "Modern Statistical Methods," by James MacDonald Troup, M.A. St. And., B.A., M.B., B.C. Cantab, and G. Dare Maynard, F.R.C.S. Edin., M.R.C.S. Eng., L.R.C.P. Lond. *Lancet*, May 14, 1910.

likelihood of a similar happening in like circumstances. Mere columns of figures, however exact they may be as records of facts, are both useless and dangerous if they are not scientifically analysed. Formulæ are the necessary shorthand of every science. Chance occurrences fall into a definite order when a sufficient number of them are examined. Statistical data assume corresponding regularity and fall under a similar law of distribution. Correlation is a very important branch of statistics. It was initiated by Galton and perfected by Karl Pearson. It is the means of measuring the interdependence of events.

Theory of Probability.—The object of the theory of probability is to obtain accurately a measure of the likelihood of the occurrence of events under conditions, some of which are known and some unknown. The probability of the occurrence of an event is expressed by a fraction, the numerator of which represents the number of ways an event can happen and the denominator the sum of the number of ways in which it can happen and in which it can fail. For example, if a person holds one ticket in a lottery in which there are three prizes and seven blanks, the number of ways in which the event—winning the prize—can happen is three, and the number of ways in which it can fail is seven. The probability of his winning a prize is therefore $\frac{3}{10}$. The probability of not winning a prize is $\frac{7}{10}$. The probability of his either winning a prize or not winning one is $\frac{10}{10}$ or unity that is certainty. The measure of the probability may vary from unity—which denotes absolute certainty of the occurrence—to zero, which means absolute certainty of its non-occurrence. If a coin be tossed the probability of a head turning up is $\frac{1}{2}$, for the event can only happen in one way and fail in one way. Similarly, the probability of a tail is $\frac{1}{2}$. If two coins be tossed there are four results, viz., H.H., H.T., T.H., T.T., where the first letter is supposed to belong to one coin and the second to the other. There is therefore one result in which two heads may turn up, one in which two tails may turn up, and two results in which one head and one tail may turn up. The respective probabilities are therefore, no heads $\frac{1}{4}$, one head and one tail $\frac{1}{4}+\frac{1}{4}=\frac{1}{2}$, and two heads $\frac{1}{4}$. By following this line of argument it may be shown that if three coins be tossed the different possible results and their respective probabilities are:— 0 heads $\frac{1}{8}$, 1 head $\frac{3}{8}$, 2 heads $\frac{3}{8}$, and 3 heads $\frac{1}{8}$. The probabilities are given by the successive terms of the expansion of the binomial $(\frac{1}{2}\times\frac{1}{2})^n$ where n = 2, 3, 4, etc.

Take ten coins. If thrown the respective probabilities are:—

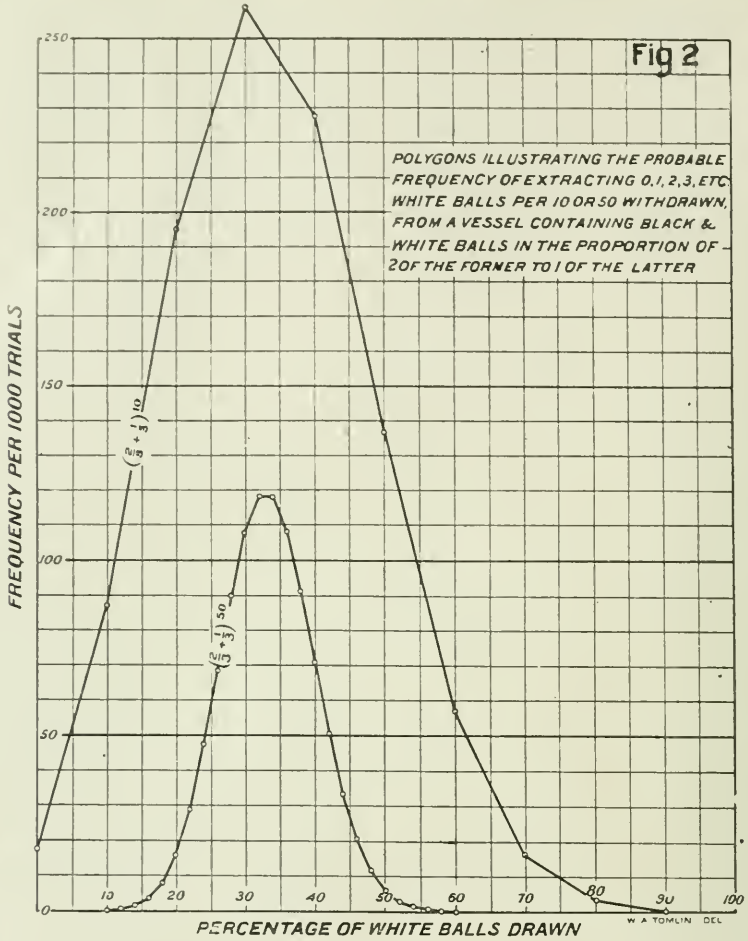
No. of heads.	Probability.	No. of heads.	Probability.
0	$\frac{1}{1024}$	6	$\frac{210}{1024}$
1	$\frac{10}{1024}$	7	$\frac{120}{1024}$
2	$\frac{45}{1024}$	8	$\frac{45}{1024}$
3	$\frac{120}{1024}$	9	$\frac{10}{1024}$
4	$\frac{210}{1024}$	10	$\frac{1}{1024}$
5	$\frac{252}{1024}$		

This result may be represented graphically on squared paper. The horizontal or x axis is divided into equal distances to represent the number of heads turned up, and the vertical or y axis is divided on some convenient scale to represent the frequency with which these events occur. If the above result is plotted item for item and the points joined, we shall obtain a frequency polygon to represent this distribution of events. This polygon is symmetrical about its central ordinate.

Take another example. If from a bag containing 40 black and 20 white balls, 10 balls be drawn at random these may be: 1, all black; 2, one white and nine black; 3, two white and 8 black, and so on. The chance of drawing a black ball is to that of drawing a white ball as 2 : 1. If 10 balls are drawn on each occasion the chances of drawing 0, 1, 2, 3, etc., white balls are given by the consecutive terms of expression $(\frac{2}{3}+\frac{1}{3})^{10}$, and the resulting probabilities are:

No. of White Balls.	Frequency per 10,000
0	173
1	867
2	1,950
3	2,601
4	2,276
5	1,366
6	571
7	163
8	30
9	3
10	0

This polygon differs from the previous one



in that it is not symmetrical; the greatest ordinate is two spaces distant from the middle of the base and the polygon tails off to the right. In both examples the ordinates increase in magnitude from left to right till they reach a maximum, and then decline again until they almost vanish. The maximum ordinate represents the frequency of the particular arrangement which is most likely to occur. Thus in the last example there are more likely to be three white and seven black balls than any other combination. If a sufficient number of trials be made, all the different combinations will occur in perfectly definite proportions, and will be distributed according to a definite mathematical law.

A rare event, such as drawing 10 white balls from the bag, is as much an essential part of the law as the drawing of any of the more frequent combinations. If therefore in a large series of events the rare event does not occur sufficiently often there would be ground for suspecting some unrecognised factor influencing the result in the same way as if it occurred too often.

If now instead of taking 10 coins, 50 were taken for experiment, the number of sides of the polygon will be so increased that the lines joining these points will appear as a continuous curve. Such a curve is known as a "frequency curve." The *mode* of a frequency curve is the abscissa of its greatest ordinate, *i.e.*, the numerical value of the combination or the event which occurs more frequently than any other.

The *mean* of a frequency curve or polygon corresponds to the abscissa of the centre of gravity of the figure, *i.e.*, it is the average of the abscissæ of all the cases.

The mean is determined by multiplying each abscissa by the frequency corresponding thereto, summing the products and

dividing this sum by the sum of the frequencies. Thus, taking our first example:

No. of Heads.	Frequency.	Product.
0	1	0
1	10	10
2	45	90
3	120	360
4	210	840
5	252	1260
6	210	1260
7	120	840
8	45	360
9	10	90
10	1	10
	1024	5120

$$\text{Mean} = \frac{5120}{1024} = 5$$

A close approximation to the general case $(p+q)^n$ when n is large, is given by the curve

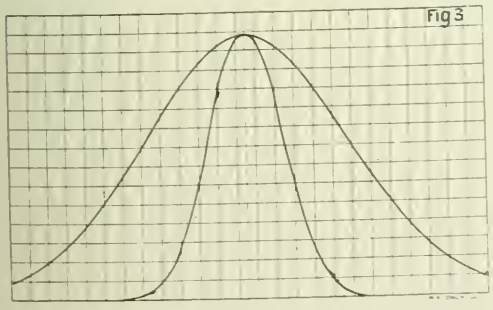
$$y = y_0 e^{-\frac{x^2}{2\sigma^2}}$$

$$\text{where } y_0 = \frac{N}{\sigma\sqrt{2\pi}},$$

and N being the total frequency while $\sigma = \sqrt{npq}$ This illustrates the change from the discontinuous binomial to the continuous curve.

Karl Pearson illustrates the position of the mean by imagining the various frequencies as weights suspended at equal distances along a uniform straight rod. The centre of gravity of the rod thus weighted is the position of the mean. While the terms "mode" and "mean" are strictly defined as abscissæ, *i.e.*, lines measured from the origin along the axis of x—it is sometimes convenient to speak of the points where these lines terminate as the position of the mode or the mean.

It is necessary to have a measure of the extent to which a distribution is spead out. Frequently two distributions when compared may have the same mean, but the



deviations from the mean may be very different. This measure is called the Standard Deviation, and is defined as the square root of the mean of the squares of all the individual deviations. Calling this standard σ, it is found by summing the frequencies of the events multiplied by the squares of their distances from the mean, dividing by the total frequency and extracting the square root of the result

Suppose we take the example used for determining the mean, we have

$5^2 \times 1$	25
$4^2 \times 10$	160
$3^2 \times 45$	405
$2^2 \times 120$	480
$1^2 \times 210$	210
$0^2 \times 252$	0
$1^2 \times 210$	210
$2^2 \times 120$	480
$3^2 \times 45$	405
$4^2 \times 10$	160
$5^2 \times 1$	25
1,024	2,560

$$\sigma = \sqrt{\frac{2560}{1024}} = 1{\cdot}58$$

The standard deviation of a distribution corresponds to the radius of gyration in dynamics. The standard deviation is a measure of the variability of any particular distribution and is a concrete number, the magnitude of which is dependent upon the magnitude of the classes. If we wish to compare the variability of two different distributions we must reduce their standard deviations to a common base. This is given by the co-efficient of variation which is the percentage of the standard deviation on the mean, *i.e.*, $\frac{\sigma \times 100}{\text{mean}}$. The measure of skewness is the difference between the mean and mode divided by the standard deviation. The skewness is positive when the mean is greater than the mode.

We shall endeavour to show that frequency of occurrence of events fall into distributions of the same type as these purely chance ones, that they are not chaotic but follow definite and determinate laws, and that by examining the nature of a particular distribution much more can be learned therefrom than appears from the ordinary methods of statement. The simplest form of curve is known as the "Normal Curve of Error." Mathematicians on the assumption that there is a large number of sources of error, and that the results are equally likely to be positive or negative, have shown that the distribution of the final errors gives a particular form of curve. This curve is symmetrical about

the mean, and extends indefinitely to the right and left but at a short distance from the mean becomes asymptotic to the axis of X, *i.e.*, practically coincident with it. Its equation, taking the ordinate through the mean as the axis of y is $y = y_0 e^{-\frac{x^2}{2\sigma^2}}$ where y_0 is the greatest ordinate, and σ the standard deviation. Although this type of curve was principally studied in connection with investigations into the probable value of errors of observation in astronomy it applies to a number of statistical distributions besides. As an example, we shall consider the coin-tossing experiment already referred to. The experimental result of tossing 10 coins 1,024 times is given in the annexed table.

No. of heads.	(1)	(2)	(3)
0	0	2	1
1	8	10	10
2	30	43	45
3	122	117	120
4	232	211	210
5	248	258	252
6	196	211	210
7	108	117	120
8	37	43	45
9	14	10	10
10	0	2	1
	1,024	1,024	1,024

For the sake of comparison, this table contains, (1) the experimental numbers; (2) the numbers given by the curve

$$y = 258 \,.\, e^{-\frac{x^2}{2 \times 2{\cdot}5}}$$

(3) the theoretical numbers given by the expansion of the binomial $(\frac{1}{2} + \frac{1}{2})^{10}$.

To Prof. K. Pearson is due the credit of having evolved a method for calculating the constants of curves, one form or another of which can be applied to any set of statistical figures which are in any way of the nature of a chance distribution. The system of curves falls into three main types with four subsidiary types which are limiting and, therefore, simpler forms of the main types. The same fundamental differential equation

$$\frac{1}{y}\frac{dy}{dx} = \frac{x+a}{b_0 + b_1 x + b_2 x^2}$$

applies to all, and the equation which results from integrating this depends upon whether the roots of the quadratic

$$b_0 + b_1 x + b_2 x^2 = 0$$

are real and of like sign, real and of different sign, or imaginary.

In the case of reef values, we cannot assay every bit of ore which comes from the mine, and have to be content with sampling portions of the whole. If these samples are to give reliable results, great care must be taken to see that the sample is strictly a random one, that is to say, that it has not in any way been selected in respect to value or any other quality that is associated in any degree with the value we intend to measure. For example, if we intend to study the distribution of values in a reef it would not be right to select only the richest or poorest stopes for study of section values. Account must be taken of all section values to determine the weights to be attached to individuals. If we wish to know how far the results calculated from our samples may be taken as representing the general value, *i.e.*, if we require a measure of the degree of accuracy with which the constants of the sample would agree with those we should obtain had we been able to deal with the whole, we must find the probable deviation, which is defined as the limit on either side of a given measurement, within which, it is an even chance that the true value lies. The probable deviation of the mean is equal to $\frac{6745\sigma}{N}$. This shows the direct relation of the size of the probable deviation to the standard deviation.

We shall imagine that we are in possession of a perfect sampler, one who has had a very wide experience, is conscientious, and has as far as possible eliminated all gross errors of sampling. The methods he has employed in conducting the actual work of sampling leave nothing to be improved upon. Likewise the assaying has been conducted as accurately as possible. Will the results obtained from this sampling and assaying represent the value recovered in the mill? Usually not, and the estimate is invariably in excess of the mill return. The discordance between mine estimate and mill return is not entirely due to deficient sampling, but in a large measure to the want of appreciation of the laws governing the weighting of facts. Samplers, as a general rule, are not as careless as they are given credit for. They endeavour to perform their duties to the best of their abilities The remedy for the above-mentioned discordance is not "Sack the Sampler."

An endeavour should be made to study the causes which give rise to these discrepancies and make due allowance therefor.

Each year thousands of samples are taken on each reef in each mine. The arithmetic mean of stretches are taken, and these used to determine the profitability or otherwise of each particular block. Should they occur in an unprofitable area they are consigned to the limbo of forgotten things. These sample sections have cost a considerable amount in accumulation and should be looked upon as very valuable facts to be made the fullest use of in future estimates.

In this paper the unit of value will be taken to be the inch-pennyweight, that is to say, a value occurring over a width. It will assist to co-ordinate the ideas if we invariably think of the value in association with the width over which that value occurs.

A close study of the distribution of values shows that when arranged in order of inch-dwts. the frequency of occurrence is low at zero, rises rapidly to a maximum and then falls gradually as the values increase to a limit where it approaches zero. The frequency of occurrence of a given value may be thus regarded as a function of the value itself.

If we denote a given value by "a" and its relative frequency in a large number of cases as $\phi(a)$. When $a=o$, $\phi(a)$ is usually very small, it then increases very rapidly up to a maximum when $a=$D, say, so that ϕ(D) is the greatest frequency. As a increases beyond D the frequency drops and ultimately approaches zero. If we denote the relative frequency or probability of a value by y, $y=\phi(a)$, may be considered as the equation to a curve, taking a as abscissa and y as ordinate. It remains to discover the nature of this curve. In dealing with a large number of section values, if there are n values equal to a, n^1 equal to a^1, etc., and the whole number of values considered is m, the probability of occurrence of the values are respectively

$$\phi(a)=\frac{n}{m}\ ,\ \phi(a^1)=\frac{n^1}{m}$$

and the sum of these is

$$\frac{n+n^1+\text{- - - - -}}{m}=\frac{m}{m}=1$$

The continuity of the curve requires that the difference between the successive values of a should be infinitesimal, hence the number of values of a is infinite, and the probability of any one of these values a is infinitesmal. To meet this difficulty it may be observed that if a finite series of values a, a^1, a^{11}, etc., be expressed in the smallest unit employed in the sections and these values are arranged in order of their magnitude, they will be a series of consecutive integral numbers. The probability of a value, a may be taken as the probability that the value lies between a and $a+1$, and the probability of a value lying between a and $a+i$, say, will be the sum of the probabilities of the values a, $a+1$, $a+2$ . . $a+(i-1)$ occurring. If i is very small, the probability of each of the values from a to $a+i$ will approximate to a, and their sum will differ very little from $i\phi(a)$. As the interval diminishes this expression becomes more accurate, hence we may take the infinitesimal da for i, and $\phi(a)da$ is the rigorous expression for the probability that a value falls between a and $a+da$. It follows that the probability that a value falls between the limits a and b is the sum of all the elements $\phi(a)da$ between these limits, and is expressed by the integral

$$\int_a^b \phi(a)da$$

This integral between the extreme limits of value and thus embracing all possible values will be

$$\int_{-l}^{+l} \phi(a)da=1$$

We have heretofore assumed that the function $\phi(a)$ is to be zero for $a=\pm l$. It must also be added that since the probability of any value greater than $\pm l$ is also zero, we should have to determine this function in such a manner that it would be zero for all values from $+l$ to $+\infty$ and from $-l$ to $-\infty$ The obvious impossibility of determining such a function leads us to extend the limits $\pm l$ to $\pm\infty$ and to take

$$\int_{-\infty}^{+\infty} \phi(a)da=1$$

This will evidently be allowable if the integral taken from $\pm l$ to $\pm\infty$ is so small as to be practically insignificant.

The Law of Errors or Simple Gaussian Law assumes that in observations made with care by practised observers, errors in excess and errors in defect are equally probable, and that the most probable value of a series of observations of the same thing is their arithmetic mean. The expression

obtained to represent the law may be shown to be

$$y(x) = \frac{h}{\sqrt{\pi}} e^{-h^2x^2}$$

Where $y(x)$ denotes the theoretical frequency of occurrence of the value x.

h denotes $\frac{1}{\varepsilon\sqrt{\pi}}$ where ε is the mean of all the values considered.

e denotes the base of natural logarithms.

In statistics, however, it frequently happens that the chances on either side of the mode or value which has the highest frequency are not symmetrical. The fall from the mode may be less rapid than the rise thereto. We then encounter a skew curve of frequency.

This curve may be imagined as compounded of halves of two symmetrical curves associated in such a way that the position of the mode for each curve is the same as for the other and likewise the frequency. The mean value on either side of the mode, however, is not the same.

The mode is determined to satisfy the condition that the mean values on either side thereof divided by the corresponding sum of the frequencies are in equilibrium. Thus, let ε_1 and ε^1 be the mean values below and above the mode and measured from the mode and m_1 and m^1 the total frequencies below and above the mode, the above condition becomes

$$\frac{\varepsilon_1}{m_1} = \frac{\varepsilon^1}{m^1}$$

This gives rise to the Compound Gaussian Law. In this law it is assumed that the most frequent value or mode determined by the proportional law is the most probable value in a similar way to the assumption of the arithmetic mean in the Theory of Errors. On these assumptions it may be shown that the equations for the curves on each side of the mode are

$$y(\delta_1) = \frac{2h_1}{\sqrt{\pi}} e^{-h_1^2\delta_1^2}$$

$$y(\delta^1) = \frac{2h^1}{\sqrt{\pi}} e^{-h^{12}\delta^{12}}$$

Where the values h_1 and h^1 must satisfy the condition $h_1m_1 = h^1m^1$.

Another hypothesis may be constructed, supported by a close consideration of the distribution of values which indicates that the Compound Gaussian Law is an approximation to the simple law of distribution. This is termed by Fechner the Law of Assymetry.

The theory of the subject of probability has been developed with a fair amount of detail in order to show that when events occur with apparent promiscuity, by detailed study the occurrence will be found to conform to some law. The trouble is to find the law. The astronomer investigates every set of observations in order to test the amount of credence he may place on the result. He determines from the observations the weight he may attach to them. In a similar way by the study of sample values for a particular reef or mine we may determine from the frequency of the occurrence of different values the relative weight we may attach to them when they occur in stopes.

The procedure adopted for this determination is to take all the recorded section values in stopes over twelve months say. Arrange them in order of value and note the frequency of values between certain intervals. An interval of 50 inch-dwts. is a convenient unit of interval. Determine the mean and the standard deviation, also the mode by means of the proportional law. When the means and frequencies below and above the mode have been determined in finding the mode, it is a simple matter to calculate the theoretical frequencies for each interval of value by the equation

$$y = \frac{2h^1m^1}{\sqrt{\pi}\, m} e^{-h'^2\delta'^2}$$

where $h' = \frac{1}{\varepsilon^1\sqrt{\pi}}$; m^1 = sum of frequencies above the mode, m = sum of frequencies above and below the mode, δ^1 = the deviation of any value above the mode. e = base of Neperian logarithms. ε^1 = mean of values above the mode, taking the mode as origin.

Similarly, the portion of the curve for values below the mode is found from the equation

$$y = \frac{2h_1m_1}{\sqrt{\pi}\, m} e^{-h_1^2\delta_1^2}$$

Here $h_1 = \frac{1}{\varepsilon_1\sqrt{\pi}}$; m_1 = sum of frequencies below the mode

m as before = sum of frequencies above and below the mode.

e = base of Neperian Logarithms.

e_1 = mean of values below the mode taking the mode as origin.

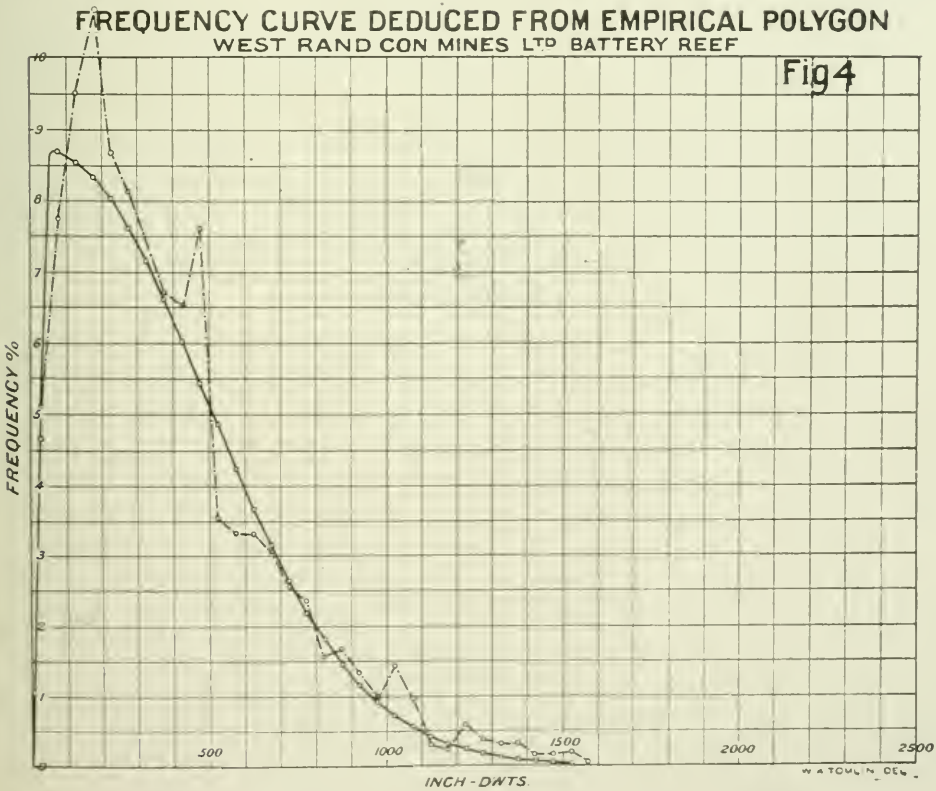
When the curve has been determined on the 50 inch-dwt. intervals, the frequencies for the intermediate values are obtained by interpolation and a table is constructed for inch-dwts. with the corresponding weight and product. This is illustrated by the accompanying table for the Battery Reef on the West Rand Consolidated Mines.

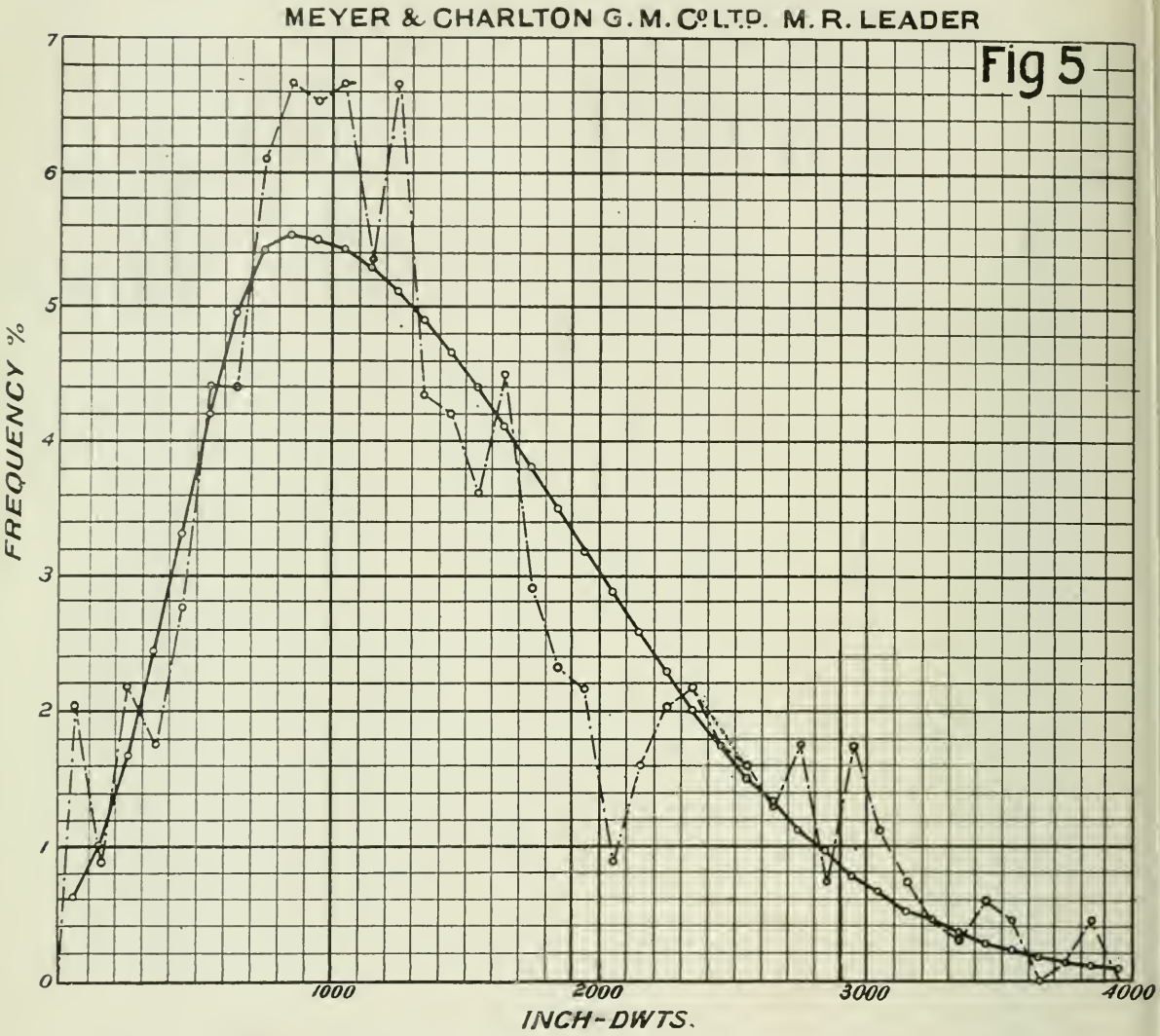
WEST RAND CONSOL. MINES, LTD.

Battery Reef.

Inch Dwts.	Weight.	Weight Inch. Dwts.
25	4·66	116·5
75	8·69	651·8
125	8·53	1066·3
175	8·32	1456·0
225	8·02	1804·5
275	7·60	2090·0
325	7·13	2317·3
375	6·60	2475·0
425	6·02	2558·2
475	5·42	2574·5
525	4·84	2541·0
575	4·23	2432·3
625	3·66	2288·0
675	3·13	2113·0
725	2·63	1907·0
775	2·18	1690·0
825	1·80	1485·0
875	1·45	1269·0
925	1·16	1073·0
975	0·92	897·0
1025	0·71	728·0
1075	0·55	591·0
1125	0·41	461·0
1175	0·31	364·0
1225	0·235	288·0
1275	0·16	204·0
1325	0·12	159·0
1375	0·086	118·0
1425	0·058	83·0
1475	0·04	59·0

To illustrate the use, suppose we have a series of section values of which the probable mean is required, we proceed thus:





Values.	Weights.	Products.
520	4·898	2547
340	6·968	2369
860	1·555	1337
730	2·585	1887
490	5·246	2570
1260	0·1825	230
1040	0·662	689
	22·0965	11629

$$\frac{11629}{22{\cdot}0965} = 526$$

The weighted mean therefore is 526 inch-dwts.

The mechanical work of meaning differs very little in amount from previous custom. Weights are not absolute quantities. They are relative, and can only be applied when correlating different values of the same thing. When we wish to obtain the value of a stope face, we may have ten or twenty samples each purporting to represent the value of the face. Our object is to obtain the most likely value of the rock from the face. We take what is termed the weighted mean as the most likely value, that is to say, each value is multiplied by the proportional frequency of its occurrence among the samples taken in the past. It is not possible to obtain a weighted value of one sample since that is the only evidence before us, and there is nothing from which we can determine the absolute probability thereof.

The prediction or, rather, comparison of estimated gold content from sampling

as against mill yield plus pulp has been tried by this method on the Van Ryn G.M. Estate during the six months ending 31st December, 1918. Assuming the estimate to be 100, the actual mill yield plus pulp has been:

July	108·6
August	105·1
September	105·1
October	105·8
November	102·4
December	99·8

In December the employment of the method on six different mines gave the following results:—

Van Ryn	99·8
New Goch	85·2
Meyer and Charlton ...	101·7
Aurora West	104·2
Roodepoort United ...	99·3
West Rand Consolidated	94·2

ILLUSTRATIONS.

1. Probability Polygons for coin tossing. These have been calculated from the terms of the binominals shown on each polygon. It will be seen that as the number of coins employed is increased the number of sides of the polygons increase until they approach the form of a continuous curve. The dotted figure is an actual result of 1,000 throws of 10 coins.

2. Polygons illustrating the probable frequency of extracting 0, 1, 2, 3, etc., white balls per 10 or 50 drawn from a vessel containing black and white balls in the ratio of 2:1. This shows the skew polygon as distinct from the symmetrical polygons in the last illustration, also the approach of the polygon to the curve.

3. This shows two curves with the same mode and the same maximum frequency, but differing in standard deviation.

4 and 5 are two curves deduced by the compound Gaussian Law from the experience of the sample sections for the year 1917.

The author's thanks are due to Sir George Albu, Bart., the Managing Director, for permission to reproduce the data and illustrations from actual practice on the mines of the General Mining and Finance Corporation.

The method is in its initial stages, and some unforseen circumstance may occur to show that the premises of the argument are wrong. The results up to the present, however, are very encouraging. Accuracy is not claimed for the method, but the results are more probable than those obtained by previous methods.

Criticism is cordially invited, as too much importance cannot be placed on the fact that our methods of valuation need improvement.

Mr. A. E. Hooper *(Visitor)*: One approaches the thorny subject of mine valuation with diffidence and mistrust of one's judgment, but the writer was led, both by observation of the ever-varying characteristics of reefs and zones of reef, and by the unfortunate results attending some of our mining ventures, to ask himself in what direction a method should be sought, based solely on scientific lines free from personal influence, which would reveal both the value and intrinsic merits of these reefs.

The method of Mr. Denny, perhaps the most sharply defined, had the fatal defect of *a priori* assumption of probability, which in effect might be misleading. After much thought on the subject, the writer was convinced that the mass of data available on most mines must form the groundwork of a method of scientific correlation drawn from the internal evidence of the mine itself.

The first researches, having for their object the application of an exact method to assays only, proved abortive. The facts were there and the theory had to fit them. Then I came to regard these data as an immense series of observations on the values of tonnage, from which, when classified, it was possible to deduce the frequency of the various values, and consequently the tonnages corresponding to them, without really interfering with a single observed value.

The analysis of nearly 6,000 individual sampling results from two reefs was undertaken, drawn from the working places in ore reserves. This number I found to be in the particular instance sufficient to stabilize the results, and reflect the actual conditions in the mine. As a matter of convenience, these were classified in ranges of 100 inch-dwts. up to such limit where the number of occurrences became so few as to justify for the time their inclusion in one class, and of course the reefs were kept distinct. The percentage of occurrences in each class to the total number of observations was taken, and consequently gave at once the percentages of tonnage coming from the various classes, and at the same time threw into strong relief the merit and

peculiar character of gold distribution of each reef.

In plotting these data for each reef, the tonnage weights on the vertical axis and the inch dwts. ranges on the horizontal, a series of points defining the outline of two fairly regular curves resulted, constituting the curve of probability of Value Frequency for the particular reef in question, and it became an easy matter to find for any range of sampling results the relative frequencies or weights by which to multiply them to obtain the correct result. Each individual result being multiplied by its known weight and the sum of these multiplicands divided by the sum of the weights.

A further examination of about 4,000 development results to ascertain in the particular reefs whether the increase in gold content of the Pay Reserve was due to any particular predominance, showed that on the whole the increase in value was due mainly to a greater frequency of the middle categories.

It is of course clear that frequencies drawn from the whole of the reef are inapplicable to Pay Reserves, as it is the aggregation of good values in particular areas that constitute their payability, and it is these frequencies that it is above all necessary to determine.

For the analogous reason, on large mines the same reef often has well marked differences in the gold distribution, which should be taken account of by a sub-division into sections or zones, so as to reflect as nearly as possible these characteristics.

It remains to prove the validity of the method under varied conditions.

NOTES ON THE REMOVAL OF A VERTICAL SHAFT PILLAR.

By J. Chilton (Member of Council.)

(Printed in Journal, June, 1917.)

Mr. B. C. Forrest *(Associate):* In the author's paper there are several statements that call for criticism, as they seem to lead one to conclude that the shaft pillars advocated by mining authorities are useless on the Rand, whereas the figures given are by no means convincing.

TABLE.

AUTHORITY.	Area of Shaft Pillar. Depth of Shaft = 1,500 ft. Width of Seam = 5 ft. (assumed). Square.	Circular.	FORMULA. A = Diam. of Circular, or side of square at surface. S = Depth of Shaft in Feet. D = Diam. of Circular, or side of square pillar, in feet. W = Width of Seam in feet.
	Sq. Ft.	Sq. Ft.	
Andre	99,000	78,000	$D = 15 + \frac{S}{5}$ = 315 ft.
Foster	270,000	212,000	$D = 6\sqrt{SW}$ = 520 ft.
Hughes	2,250,000	1,768,000	$D = S$ = 1,500 ft.
Lupton	998,000	784,000	D = = 999 ft. (Author unknown to me)
Merivale	22,000	17,000	$D = 66\sqrt{\frac{S}{300}}$ = 147 ft.
Pamley	176,000	139,000	$D = 45 + \frac{S}{4}$ = 420 ft.
Wardle	164,000	129,000	$D = 30 + \frac{S}{4}$ = 405 ft.
Dron	1,040,000	817,000	$D = A + \frac{2S}{3}$ = 1,020 ft.
Roberton	345,000	271,000	$D = \frac{S}{3} + \sqrt{SW}$ = 587 ft.
"Mining Engineering," (London)	257,000	202,000	$D = 120 + \frac{S\sqrt{\frac{W}{3}}}{5}$ = 507 ft.

The author says, "If the sizes of shaft pillars here outlined were sufficient with the soft thill of a coal seam, it might reasonably be supposed that a much larger pillar standing on hard quartzites would be sufficient to resist . . . . ." This statement suggests, if it does not definitely affirm, that the 60,000 sq. ft. pillar which collapsed at the Village Main Reef was "much larger" than it would have been if its size had been determined by the formula of any of the authorities quoted, whereas, according to the table given by the author, it was *smaller* than any except Merivale's.

When they are all expressed in the same unit, one is better able to compare the size of the Village Main Reef shaft pillar with that of one based on the several rules of the authorities quoted by the author. I therefore give the area of a pillar demanded by each of these authorities together with three others. I also append (see table on previous page) their respective rules as formulae, because my figures do not quite agree with those quoted by the author.

I think the apparently divergent views of the above authorities are not so remarkable when we remember that the rules were formulated under widely varying conditions.

In the paper, we are not told the position of the Village Main Reef shaft with respect to the boundaries of the pillar; nor is very much information conveyed by the illustrations as the North point has been omitted, and, as Mr. Woodburn pointed out, the amount of pillar left on the rise side of a shaft should be greater than that left on the dip side. After a considerable amount of research, M. Fayol concluded that "in stratified deposits the zone of subsidence is limited by a dome-shaped figure, having for its base the area excavated, the extent of the movement diminishing the farther one departs from the centre of the area." If it were possible to determine the maximum height of such a dome in Rand formations, a fairly accurate formula might be deduced which could make a liberal allowance for "draw."

I had hoped that some of our responsible engineers would have told us how they decide what size of shaft pillar to leave under different conditions, as it seems that too often, in questions such as this, financial interest, and not mining science, dictates the policy.

Obituary.

Mr. E. G. Baskett.

It is regretted that the influenza epidemic has claimed another victim in Mr. Edmund Graham Baskett, an Associate of the Society since January, 1911. Mr. Baskett was a native of New Zealand, where he commenced his metallurgical career, being connected with the Talisman Consolidated, the Waihi, and the Waihi Grand Junction Mines. After working up to the position of a Battery Superintendent, he came to South Africa in 1910, holding various appointments at the New Modder, Modder B., City and Suburban and Rietfontein T.C.L. In August, 1914, he left South Africa to take up the position of Reduction Officer at Prestea, Block A, West Coast of Africa. This position he resigned on obtaining a commission in the Nigerian Regiment, serving with the West African Frontier Force until nearly the end of the war. Influenza, together with pneumonia, caused his death on October 27th, and much sympathy is extended to his relatives in their loss. Mr. Baskett was a man of exceptional attainments, and in his premature death metallurgy has sustained a great loss.

Mr. Daniel Joseph Pepler.

The death is recorded of yet another victim to influenza of Mr. D. J. Pepler, for many years mill manager at the Ferreira Deep, Ltd., who died on the 27th October.

Mr. Pepler was devoted to his work, and contributed to the discussion on nearly every paper dealing with milling and amalgamation. He also devised a driving device to Challenge Feeders, which was described in a short paper printed in the *Journal* for August, 1907. He joined the Society as a member in September, 1899. The sincere condolences of the Society will be with his widow and children in their bereavement.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Carbonisation of Coal.—"Whilst the chief aim of high-temperature carbonisation is the production of a maximum yield of gas, the aim of low-temperature carbonisation is the production of an easily ignitable coke burning brightly with practically no smoke. In addition, from coals, cannels, shales, and lignite, quantities of oil may be obtained varying from 16 gallons in the case of colliery refuse to 87 gallons in the case of cannel.

From these, petrols, burning oils, Diesel oils, lubricating oils, paraffin wax, tar acids, and a valuable bituminous pitch, can be obtained. The gas is 'stripped' to recover additional petrol, and this, together with the petrol obtained by fractionating the crude oils, gives a total of 4 to 8 gallons of petrol per ton of coal. The gas after 'stripping' is used as retort fuel. The above results are obtained by carbonising in iron retorts of special construction at a temperature from 900° to 1,200° F. (480° to 640° C.) and under a vacuum of 10 in. to 20 in. of mercury. The author and his colleagues claim to have established the fact that 5 in. is the maximum thickness of charge for low-temperature processes, and have on hand several large installations, in all of which retorts taking 1 ton per charge of fours hours will be installed." —F. D. Marshall, *Ges. J.*, 1917, *140*, 465.—*Journal of the Society of Chemical Industry*, Jan. 15, 1918, p. 2a. (J. A. W.)

Recovery of Potash as By-Product of the Cement Industry. — "The process described previously has been applied to the flue dust from cement kilns. The potash present can be liberated and volatilised completely by heating felspar mixed with lime for one hour, on a laboratory scale. A similar reaction takes place in the cement kiln between the constituents of the charge containing lime and potash, and a greater or less proportion of the latter is volatilised, appearing in the flue dust. This, when fresh, consists of sulphates, sulphides, and chlorides of potash, soda, and lime. The proportion of sulphides is greater in oil or gas fired kilns. Free lime is present and the extract is alkaline. Analyses of the raw mix and cement clinker from 113 works in America permitted an estimation of the amount of potash recoverable. The raw mix contained from 0·2% to 1·16% of K_2O and the analyses showed that the weight of potash volatilised per barrel of cement varied from 0·35 lb. to 5·34 lb. Omitting plants using blast-furnace slag, the average of 99 plants was 2·09 lb., which means an annual production for the United States of about 87,000 tons of K_2O volatilised. By electrical precipitation (Cottrell process) 99% of the flue dust can be precipitated, but as the lighter portions are richer in potash, only 90% of the potash is thus recoverable, *i.e.*, 78,000 tons on the above basis. When the kilns are coal-fired, the proportion of soluble potash in the dust is lowered —59·6% in one case, against 91·6% in an oil-fired kiln. Laboratory experiments show that the process described above—digestion with lime water under pressure—renders 90% of the potash soluble in ½ hour at 100 lb. pressure and 95% after 8 hours. Assuming a 90% yield of soluble potash, the annual production would be 70,000 tons or, excluding plants volatilising less than 1 lb. K_2O per barrel, 67,000 tons. This, however, could be materially increased by increasing the proportion of potash in the raw mix. Where aluminiferous cements are made, felspar alone can be added, whilst for silicious cements, felspar and a suitable proportion of iron ore would be necessary. In one case the proportion of K_2O volatilised was increased from 38% to 65% by the addition of salt to the raw mix. The percentage of total alkali in the finished cement was thereby reduced. In another works calcium fluoride was used and the potash driven off as potassium fluoride. On leaching the dust with hot water the calcium and potassium compounds reacted, regenerating the calcium fluoride in the insoluble residue and leaving the potash in solution as sulphate or carbonate. The insoluble residue was returned to the furnace and in this way the proportion of potash volatilised was increased from 60% to 90%. In some works the proportion of potash volatilised can be increased by raising the temperature of the 25% to 96% and it is considered that by rational working the lower figures could be much increased. If an average yield of soluble potash equal to about 50% could be attained —and experience shows this is possible—then an annual production of 100,000 tons of K_2O could be realised. The treatment of cement flue dust by electrical precipitation and recovery of soluble potash is being rapidly extended in American plants."—W. H. Ross and A. R. Merz, *J. Ind. and Eng. Chem.*, 1917, *9*, 1035-1038.—*Journal of the Society of Chemical Industry*, Jan. 15, 1918, p. 9a. (J. A. W.)

Manganese in West Africa.—"The cutting off or curtailment of the supplies of manganese ore from Russia, India, and Brazil has rendered the development and exploitation of other more accessible sources of very great importance. The manganese deposits at Dagwin, near Taquah in the Gold Coast Colony, which were discovered by the Government Geologist in 1914, have recently been taken seriously in hand, and it is a fortunate circumstance that ore is found only 200 yards from the Seccondee-Coomassie railway, at about 33 miles from Seccondee. At this point massive outcrops of psilomelane, with a little pyrolusite, are found on the crest of a ridge running N.E. for about 2½ miles, and containing 42—53% of manganese. Similar ore also occurs further still to the N.E. Up to July 31, 1917, 20,600 tons had been shipped, having an average content of 52% manganese, 4·6% iron, 4% silica, and 0·11% phosphorus; and the total shipments up to November 28 last ran to 30,747 tons. Many difficulties have been met with, such as labour shortage, the clearing of jungle, and high transport charges (railage to the coast, 33 miles away, is 7 shillings per ton, lighterage 6 shillings and 6 pence, freight 60 shillings, plus a 10% war tax), but about 5,000 tons of ore per month can now be mined and shipped. Although no accurate estimate of the extent of the deposits can be made, the authorities are satisfied that a huge tonnage is available."—*Journal of the Society of Chemical Industry*, Feb. 15, 1918, p. 57R. (J. A. W.)

Gravimetric Determination of Potassium by Sodium Cobaltinitrite.—"The solution of the potassium salt, containing about 0·25 gm. of potassium chloride and free from other bases except sodium, is evaporated to 25 cc. and treated with 25 cc. of sodium cobaltinitrite solution (cobalt nitrate, 28·6 gm., glacial acetic acid, 50 cc., sodium nitrite, 180 gm., water to 1000 cc.). After 18 hours, the precipitate is collected, washed with 10% acetic acid, then once with 95% alcohol, dried at 100° C., and weighed. The weight is multiplied by 0·2074 to obtain the quantity of K_2O present. The method is accurate and may be applied to fertilisers, soils, wines, etc."—C. V. Garola and V. Braun, *Ann. Falsif.*, 1917, *10*, 572-575.—*Journal of the Society of Chemical Industry*, March 30, 1918, p. 168a. (J. A. W.)

METALLURGY.

Platinum: Table of World's Production and Prices Only.—"The following table shows the world production of platinum in recent years, in troy ounces:

Country.	1912	1913	1914	1915	1916	1917
Borneo and Sumatra	—	200	(a) 30	(a) 100	(a) 60	(a) 80
Canada	30	50	17,500	18,000	25,000	32,000
Colombia	12,000	15,000				
New South Wales and Tasmania ...	778	1,500	1,248	303	222	(a)
Russia	300,000	250,000	241,200	124,000	63,900	50,000(b)
United States ...	721	483	570	742	750	605
Total	313,529	267,333	260,548	143,145	89,932	82,685

(a) No basis for estimate.
(b) Some estimates place this figure as high as 100,000 ounces.

Average price per troy ounce of refined metals of platinum group, 1914-1917.

Metal.	1914	1915	1916	1917
Platinum ...	185/-	226/-	345/-	423/-
Iridium ...	267/-	341/-	386/-	617/-
Iridosmine (iridio osmium) ...	136/-	144/-	185/-	329/-
Palladium ...	181/-	230/-	275/-	452/-

—*Journal of the Society of Chemical Industry*, Sept. 16, 1918, p. 339R. (J. A. W.)

Loss of Quicksilver in Gold Mills.—"The death-knell of the stamp-mill and the amalgamation process has been so often and so loudly rung by vendors of rival machines and inventors of rival processes that one might almost suppose them to be obsolete by this time. Stamp-mills, however, continue to crush nearly all the gold ore in the world, and amalgamation is responsible for about a quarter of the gold produced in the United States, and for a still larger proportion of that extracted abroad. Mercury therefore maintains its importance in gold metallurgy, though at the present high price there is a natural and increasing tendency to substitute non-amalgamation processes wherever possible.

Much of the mercury used in the stamp mill, whether fed into the mortar or sprinkled on the plates, is collected again in the form of amalgam and condensed when the latter is 'retorted.' Only a trifling amount remains in the retorted sponge, to be volatilized and lost in melting the bullion. A larger amount is carried off in the tailing, mostly mechanically as floured quicksilver or amalgam, but partly in the form of smears on the surface of particles of ore, and sometimes partly converted into oxide or sulphide. Some of this accumulates in odd corners, or is caught in traps, and cleaned up from time to time. In the cyanide process part of the mercury in the tailing is dissolved, re-appearing later in the precipitate, from which it is sometimes profitable to recover it by distillation. A certain irrecoverable loss occurs, principally in the tailing, but in modern mills, operating on low grade gold ores, the loss per ton crushed usually ranges from about 0·005 to 0·01 lb. avoirdupois, or, say, 0·07 to 0·15 oz. troy. At the prices current for some years before the present war the cost of an ounce of mercury averaged 4 cents, a flask containing about 1,100 oz. troy. Since the outbreak of the war the price has more than doubled, averaging about 8 to 10c. per oz., and at times has been much higher. In former times, when milling high-grade ores with small plate-areas, the losses were often much larger, while the various amalgamation processes (pan, patio, barrel, etc.) applied for treating rich silver ores, consumed enormous amounts, both mechanically and chemically, especially in the days when mercury was allowed to act both as reducing agent and collector, directly replacing silver in the compounds treated.

The accompanying table is the result of an attempt to collate some of the available data on the consumption of mercury in stamp-mills of both past and present. The endeavour has been made to reduce all figures to the basis of troy ounces of mercury per short ton. In a few instances the original writers have not specified clearly what sort of ounce or ton they meant, but the errors possibly introduced in this way are not of serious importance (see table below).

Older data on Australian mills are given by A. G. Lock, 'Gold: Its Occurrence and Extraction,' pp. 638 and 1019.

A few special cases involve conditions different from ordinary stamp-mill practice, and may be separately considered.

Not much information is available as to the relative amounts of mercury used in the mortar, on the plates, etc., but some data have been published on the practice at the Homestake and Alaska mills. The former use inside amalgamation and have an unusually large outside plate area, averaging 240 sq. ft. per 5-stamp battery; the latter, before abandoning the use of mercury, also amalgamated in the mortar, each 5-stamp battery having a plate of 45 sq. ft. surface and two vanners carrying 18-in. plates.

The ultimate consumption or loss of mercury is no doubt influenced to some extent by the richness of the ore, by the area and slope of the plates, and the relation between their width and length, but more by the condition in which they are maintained as to 'dryness' or 'hardness.' Other factors are manner of feeding the mercury, whether into the mortar or outside only, the frequency of removing amalgam and dressing or brushing the plates, the kind of traps used and the attention paid to them. The nature of the ore treated, apart

from its gold content, is also an important factor, pyritic minerals generally tending to increase the loss. In small-scale laboratory tests it is, however, noticeable that highly sulphuretted ores often cause less flouring and fouling of the mercury (commonly due to formation of a film of sulphide) than those containing a smaller proportion of sulphide that is in a partly oxidized condition. Pyritic concentrates, when run through a mill after becoming partly oxidized by storage, cause rapid discoloration of plates. No particular sulphide, speaking generally, seems to cause more fouling of the mercury than another, though in individual mines or districts such an effect may be apparent.

Quicksilver Used and Lost in Homestake Mills (C. and S.)

Character of Ore.	Average.	Low-grade oxidized.	Fair-grade unoxidized.
Fed to mortar, oz. per ton	0·30*	0·27†	0·33*
Recovered from retort ...	0·37	0·18	0·50
Loss	0·132	0·085	0·17
Gold amalgamated per ton	$2·92	$1·93	$3·70

*Additional mercury was sprinkled on outside plates, and used in cleaning up.

†An additional 0·08 oz. mercury on outside plates.

Distribution of Quicksilver Used in Alaskan Mills (12)

Mill	240-stamp	300-stamp	Ready bullion	700-foot	Alaska Mexican
Fed to mortar, oz. per ton ...	0·1747	0·1792	0·1787	0·1138	0·1731
Plates	0·0143	0·0179	0·0079	0·0164	0·0114
Vanner plates	0·0015	0·0012	0·0031	0·0018	...
Cleaning amalgam	...	0·0238	0·0268	0·0534	0·0344
Total used	0·1905	0·2221	0·2165	0·1854	0·2189
Loss	0·0690	0·0820	0·0770	0·0470	0·0600

W. J. Sharwood.—*Mining and Scientific Press*, April 6, 1918, pp. 483-485. (H. R. A.)

Cyaniding in West Africa.—"*Details of Practice in Cyanide Department.*—Eight 300-ton collectors received the sand from the Wilfley tables through Butters & Mein distributors, and, when full, were discharged by hand on to a belt conveyor feeding 18 cyanide vats of 250-ton capacity. Three stock solutions were employed, namely: strong, running 0·25% KCN; medium, 0·15% KCN; and weak, 0·08% KCN. The requisite additions of cyanide were made to the strong sump. During the charging of a vat 250 lb. of lime was added and 100 lb. more used as a cover.

The treatment cycle, which required 5½ to 6½ days, was as follows:

1. Pump up first strong solution; leach until effluent has a cyanide content of 0·05%; shut cock for six hours; pump up enough to keep surface covered (about 90 tons of solution).

2. Open cock, drain dry; dig over surface as soon as dry enough to stand on; pump second strong solution; when leaching freely shut cock for six hours (about 70 tons of solution).

3. Open cock, drain as in (2); pump medium solution; shut cock for six hours (about 70 tons of solution).

4. Pump weak solution (about 175 tons of solution).

5. Pump as much water as possible.

Graphite Caused Premature Precipitation.—Trouble was experienced from graphite present in the sand. As dissolution of the gold and its premature precipitation take place simultaneously, it would seem preferable to omit any step which involves the closing of the leaching cock. A higher recovery would possibly have been made if a greater volume of solution had been drawn through the charge within the same time limits.

In making a clean-up, the following order was pursued: Shut off the solution, add 10 lb. of KCN to the head of the box and run a moderate stream of water through for two hours. The fine gold slime were transferred to two Johnson presses by means of a suction pump. The long zinc was scrubbed in the clean-up vat; the short zinc and slime below the screen in each compartment were carried to the acid vats in buckets.

Following is a record of a clean-up taken at random:

First day—Box 1: eight 15 cub. ft. compartments, 62 lb. of zinc in each; box 2: eight 15 cub. ft. compartments, 57 lb. of zinc in each; box 3: eight 10 cub. ft. compartments, 40 lb. of zinc in each. One pound of lead acetate was used for every 80 lb. of fresh zinc. Sixteen carboys of acid were required.

Second day—Box 4: 14 cub. ft. per compartment, 60 lb. zinc per compartment; box 5: 11 cub. ft. per compartment, 42 lb. zinc in each; box 6: 11 cub. ft. per compartment, 42 lb. zinc in each. Seventeen carboys of acid were used, and for every 60 lb. of fresh zinc 1 lb. of lead acetate was also used.

In smelting the precipitate, on the first day, 45 lb. of borax, 10 lb. of sand, 5 lb. of sodium bicarbonate, and 5 lb. of potassium permanganate were used to flux 82 lb. of gold slime, from which 360 oz. of bullion, valued at $5,250, was obtained. On the second day, 25 lb of borax and 5 lb. each of sand, sodium bicarbonate and potassium permanganate were used for 44 lb. of gold slime, yielding 117 oz. of bullion valued at $1,600.—P. T. Bruhl.—*Engineering and Mining Journal*, July 13, 1918, p. 54. (H. A. W.)

Chemicals Used in Ore Flotation.—"The use of flotation agents other than oils is discussed. Sulphuric acid often produces a cleaner froth and an increase in extraction, and sometimes allows of reduction in the proportion of oil used. The cause of the improvement is unknown. With certain partly oxidised copper ores, acid is fatal to good flotation. Copper sulphate (1 lb. per ton of ore) has caused higher recoveries of zinc blende in many cases, though not invariably. Probably the blende particles become coated with copper sulphide, but the reason why the filmed particles float better is not known. Sodium carbonate or hydroxide is used in many mills, but beyond the fact that the results are improved, very few observations on their mode of action have been reported.

Sodium silicate and sulphide are also employed. The last named acts by coating oxide ores with a film of sulphide. Lime is not so desirable as sodium compounds; unlike the latter, it usually flocculates the gangue slime. Tartaric and citric acids are mentioned in Eng. Pat. 17,327 of 1914; 0·1 lb. to 0·25 lb. of argol per ton of ore has been used with success on copper ores containing much clayey matter. The use of silicofluorides is claimed in Eng. Pat. 4,938 of 1914 as a substitute for acids. Sodium manganate and chromate are recommended for differential flotation; they could be made cheaply by fusing local manganese or chromium ores with soda. Sulphur dioxide, and sodium sulphate or thiosulphate in sufficient amounts inhibit flotation. Chloride of lime is said to effect differential flotation of blende from pyrite. Sodium cyanide has been found deleterious to flotation in most cyanide mills in which tailings have been tested."—O. C. RALSTON and L. D. YUNDT, *J. Ind. and Eng. Chem.*, 1917, *9*, 1058-1062.—*Journal of the Society of Chemical Industry*, Jan. 15, 1918, p. 12a. (J. A. W.)

MINING.

FORMULAS FOR MINE VALUATION.—Mr. W. Whitton, in the *Mining and Scientific Press*, May 18th, 1918, writes :—"The tables in common use for the valuation of mines are based on what is commonly known as the Hoskold formula. . .

In this paper I have undertaken to show that this formula does not correctly represent the algebraic relationship between the several quantities recognised as entering into the valuation of a mining investment, and that, at ordinary rates of interest and usual years of life, the factors based on the Hoskold formula are in error by as much as 20%. . . . .

The Hoskold formula attempts to express the algebraic relationship between present value or capital, rate of interest, and the term or years of life of a mining investment. By so doing the attempt is made to place mine valuation upon the same basis as the ordinary investment of capital, as for instance the purchase of a mortgage or a bond. On investing capital in a bond the years it has to run is not a matter of great importance, because the investor understands that a sinking-fund is being created, which, at the expiration of the term, will restore the capital. A mining investment, however, is of the class known as a wasting asset, or of that class in which the payment of returns on the investment necessarily results in the destruction of the property in which the capital is invested. Hence the term or years of life of the mine is a matter of vital importance. Other classes of investments give at least some guarantee of a return of capital, and it would be desirable that mining as far as possible should be placed upon the same basis; we should, therefore, in theory at any rate, provide for the return of the capital to an investor, as well as allow for the payment of interest according to the risk assumed.

Mining companies do not generally establish a sinking-fund that will return the capital to an investor. Possibly they should do so, as has often been claimed; but it appears that this should be left to the investor, except in special cases. During the early stages of the development of a mine the stock may be worth intrinsically but a small fraction of its par value; likewise, when the payments of large dividends are assured, the same stock may be worth many times the par value. Investors may have purchased stock throughout the entire range of prices, and the mine officials have no way of determining the price at which stock was acquired. Therefore the attempt to provide for the return of capital by mining companies seems to be improper, but it is none the less a matter of importance to the individual investor. Hoskold appears to have been one of the first engineers to recognise this principle in mine valuation, and he has shown that each dividend received by the investor is to be regarded as composed only in part of interest on the investment, and that the remainder in theory must be set aside to provide a sinking-fund that will return the capital at the exhaustion of the mine. In other words, this balance is to be regarded as an installment to be paid annually into the sinking-fund, and this portion must be of such amount that, when re-invested in a safe security, as, for example, when deposited in a bank at 4% compound interest, it will amount to the sum originally invested at the time of exhaustion of the mine.

This theory of the formation of the sinking-fund may be made clearer if the investor, in the case given by Hoskold, will regard the capital he has put in the mine as a 'loan' to the mine. The mine as the 'borrower' is to pay a proper rate of interest on the loan, and, of course, must return the amount borrowed to the lender. In view of the fact that, on the exhaustion of the mine the 'borrower' will be powerless to return the capital to the lender, each dividend must consist of interest and an additional amount sufficient, if reinvested at compound interest at 4%, to equal the amount borrowed when the mine is exhausted and dividends cease.

Upon this Hoskold has based his formula; it is sound in theory, but as an hypothesis it is incomplete. There are several ways in which the amounts paid as interest and those paid into the sinking-fund may be apportioned, and also in which the sinking-fund may be accumulated. Hoskold's hypothesis is that interest is to be paid at the stipulated rate on the entire sum originally invested during the total life of the mine; this requires a constant amount of interest each year to be taken out of the dividend, hence there is a constant instalment paid annually into the sinking-fund. I regard this division of the dividend between interest and sinking-fund as incorrect, and shall attempt to so demonstrate. The algebraic quantities entering into the deduction of the Hoskold formula are as follows :

j = the rate at which the sinking-fund instalments are to be placed at interest. This is taken at both 3½ and 4% in the United States; in England, rates of 3 and 3½%, are used. For 4% $j = 0{\cdot}04$.

i = the rate to be realized on the investment. This may vary in practice from 4 to 30, or even 40%. It is itself composed of several factors. It must be greater than j, the rate that can be realised safely on an investment with practically no risk of losing the capital. . . . .

d = the amount of annual dividend (in dollars).

n = the term of the investment or years of life of the mine.

V = the present value of the investment. . . . .

The equation arrived at is

$$V = d\frac{(1+j)^n - 1}{(1+j)^n\, i - i + j}$$

Assuming an annual dividend of one dollar, or unity, Hoskold's factors are obtained by substituting the acquired values for i and j. As a typical case, and as an aid to the discussion of the formula, take a mine with an expected life of 10 years, paying an annual dividend of $1000, the rate to be allowed on the investment to be 10%, with the sinking-fund placed at interest at 4%. From Hoskold's tables the value of this investment is $5455.80691. The following redemption table will illustrate the application of the Hoskold formula:

Year	V	Dividend d	Vi	$(d-Vi)$		Amount of sinking fund
1	$5455.81	$1000	$545.58	$454.42	$646.78	$454.42
2	5455.81	1000	545.58	454.42	621.91	927.02
3	5455.81	1000	545.58	454.42	597.98	1418.52
4	5455.81	1000	545.58	454.42	574.98	1929.68
5	5455.81	1000	545.58	454.42	552.87	2461.28
6	5455.81	1000	545.58	454.42	531.61	3014.15
7	5455.81	1000	545.58	454.42	511.16	3589.14
8	5455.81	1000	545.58	454.42	491.50	4187.12
9	5455.81	1000	545.58	454.42	472.60	4809.03
10	5455.81	1000	545.58	454.42	454.42	5455.81
					$5455.81	

The foregoing table, constructed on the hypothesis upon which the Hoskold formula is based, shows that the annual dividend of $1000 is divided, throughout the 10-year life of the mine, into two constant parts. The dividend of 10% on the capital of $5455.81 requires $545.58; and the balance, which is $1000 less $545.58, or $454.42, is paid into the sinking-fund, where it accumulates at 4% compound interest. The sixth column gives the amount of each instalment accumulated at 4% interest, compounded annually, at the end of the tenth year. The sum of this column is the amount of the original investment. The last column gives the total amount in the sinking fund at the end of each year, and the error in the Hoskold formula is plainly exhibited by this column. Consider, for example, the amount in the sinking-fund at the close of the ninth year, which the table gives as $4809.03. Of the original capital put into the mine there remains in fact only the difference between the total in the sinking-fund and the amount originally put in, or $5455.81 less $4809.03, which is $646.78; and this amount only is exposed to the risk that calls for the payment of 10% interest on the investment. The remainder of the original capital has passed through the hands of the investor and has been placed in some safe security bearing 4% interest. It is, therefore, unquestionably a fallacy to require a mine to pay a high rate of interest on the entire amount originally invested during its entire life; and more especially is this true when, as in this example, the value of the remaining one year's dividends is but $909.09. Imagine a borrower that has paid back all of a loan of $5455.81 except $646.78, which he had borrowed at 10% interest, and that he still is required to pay interest at 10% on the amount originally borrowed.

This error in the Hoskold formula and the factors based thereon seems to have passed unnoticed. The only direct reference to it that I have seen is that Inwood makes the comment, regarding the factors to be used in valuing loans, that the terms of such loans are onerous to the borrower. It even appears to be commonly assumed in mining literature that Hoskold's formula is based on the assumption that the mine does pay interest only on that portion of the capital unreturned to the investor, whereas the direct opposite is the case. Nor is this error small in amount. As I shall later show, the true value of the investment given in the above table is $6591.37, which is practically 20% greater than the Hoskold factor.*

I shall now give the deduction of a formula that rectifies this error in the Hoskold formula, and which I believe to be the correct formula to be used for mine valuation. This is based upon the same assumptions as the Hoskold formula, with the added provision that interest shall be paid at the risk-rate i only upon the unreturned capital, and that the unreturned capital shall be the amount of the original investment less the amount in the sinking-fund. The amount in the sinking-fund at any time is the amount paid into this fund out of dividends plus the added accumulations of interest at the rate j. Thus, taking V as the present value of the investment, it is the amount of the unreturned capital over the first year. At the end of the first year the annual dividend, of amount d, is paid. This dividend is made up of two parts; Vi is the interest requirement on the capital at the rate i: thus $d-Vi$ is the balance placed in the sinking-fund. For the period of the second year the unreturned capital then is, according to the hypothesis taken, $V-(d-Vi)$. At the close of the second year the dividend d is again paid. Allowing interest at the rate i on the unreturned capital, the interest requirement of this second dividend is $Vi-i(d-Vi)$; and the payment into the sinking-fund from the second dividend is the difference between the constant dividend d and this interest requirement, or $d-Vi+i(d-Vi)$. The total amount in the sinking-fund at the close of the second year is the sum of the amount paid into the sinking-fund at the close of the first year plus the interest on this first payment for one year at the rate j, plus the amount paid into the sinking-fund at the close of the second year: the expression for this is $(d-Vi)\ (1+j)+(d-Vi)\ (1+i)$.

This may be simplified to $(d-Vi)\ [(1+j+i)+1]$.

Thus, the unreturned capital over the third year is $V-(d-Vi)\ [(1+i+j)+1]$.

At the close of the third year the dividend d is again received. The computation for the third year is somewhat lengthy, but it is a matter of simple algebra to show that the sinking-fund, after the receipt of the third dividend, amounts to

$$(d-Vi)\ [1+i+j)^2+(1+i+j)+1].$$

Similarly, for the fourth year it can be shown that the sinking-fund will amount to the expression

$$(d-Vi)\ [(1+i+j)^3+(1+i+j)^2+(1+i+j)+1].$$

Obviously, then, for a life of n years, the sinking-fund will have accumulated to the amount of the following expression, which by my hypothesis equals V, or

$$V=(d-Vi)\ [(1+i+j)^{n-1}+(1+i+j)^{n-2}\ .\ .$$
$$+(1+i+j)^3+(1+i+j)^2+(1+i+j)+1].$$

The expression within the brackets is again a geometrical series with a ratio $(1+i+j)$; the sum of this series is equal to $\frac{(1+i+j)^n-1}{(1+i+j)-1}$

and, substituting this expression for the sum of the series in the above equation, the result is

$$V=(d-Vi)\ \frac{(1+i+j)^n-1}{(1+i+j)\ -1}$$

* See O'Donahue on "The Valuation of Mineral Property," Chap. III.,

Solving this equation for V_1 and grouping the terms according to their order, the result is

$$V_1 = \frac{(1+i-j)V - 1}{(1+i-j)^n + j}$$

The factor for any particular year can be computed readily from this formula by assuming V to be zero, and putting $(i+j)$ equal to J. The formula then becomes

$$V_1 = \frac{(1-J)^n - 1}{(1-J)^n + j}$$

and the value for $(1-J)^n$ may be taken directly from Table I of Hoskold's tables, pages 10 to 48. The value of the numerator and denominator in the expression may be found arithmetically, and the computation may be made by means of logarithms.

As an example of the application of the new formula, and to exhibit the difference between it and Hoskold's, I give a subsequent table constructed from the same case as that taken for the discussion of the Hoskold formula. This is the case of an investment paying a annual dividend of $1000, the life of the mine to be 10 years, the investor to realize 10% on his capital, and the sinking fund to be accumulated at 4%. The amount of capital at any period remaining invested in the mine is to be considered as the amount originally put in less the amount accumulated in the sinking fund. The present value of this investment was found by means of the new formula, as $5291.37, and the following tabulation (table III) has been constructed:

Year	(1)	(2)	(3)	(4)	Amount in sinking fund
1	$5291.37	$1000	$529.14	$529.14	$529.14
2	4529.51	1000	452.95	452.95	1000.44
3	3681.46	1000	368.15	418.42	1517.42
4	2818.84	1000	281.88	458.11	1977.43
5	1921.61	1000	192.16	501.63	2479.13
6	1000.72	1000	100.07	549.18	3028.44
7	46.61	1000	4.66	601.51	3629.95
8	954.12	1000	95.41	658.81	4288.76
9	2049.72	1000	205.07	721.50	4910.26
10	3195.78	1000	319.58	790.11	5482.06
11	4505.44	1000	450.54	865.10	6091.27

$5997.10

The second column is headed by V_1, which is the amount of capital remaining invested in the mine. The original capital is $5291.37. At the close of the first year a dividend of $1000 is received by the investor. As 10% of the capital is to be paid in interest, this despite $529.14 of the dividend. The remainder of the $1000 dividend, which is $470.86, is placed in the sinking fund. During the second year the capital remaining invested is equal to the original $5291.37 less the amount of the sinking fund accumulated, which is $470.86, leaving $4820.51. At the close of the second year interest accumulates have increased to $482.05, and the remainder of the dividend, or $517.95, which is $474.31 is paid into the sinking fund. The amount in the sinking fund at the beginning of the third year is now the sum of the two dividends or $945.17, plus interest on this sum for one year at the rate of 4%, which is $37.80, plus the amount paid into the sinking fund at the close of the second year, which was $474.31; the sum of these three amounts is $1457.28. The capital remaining invested is now the original $5291.37, less $1457.28, or $3834.09. The quantities given in the table are found in the same manner for the succeeding years.

Compare the situation at the close of the ninth year in the table constructed from this new formula, with the table constructed upon the Hoskold formula. From the new formula, at the close of the ninth year the investor has in hand a sinking fund totalling $5482.06; hence the capital remaining in the mine is only $3109.44. Hence, the interest requirement from the ninth dividend is but $310.94, instead of $482.05 as called for by the Hoskold formula. It is also clear that by adopting the formula the investor only uses that part of his capital that has not been returned to him, rather than allowing him 10% interest on the amount of his original capital throughout the entire life of the mine, the value of the investment has been increased from $4000 to $5291.37, the true value of the mine to Gardner, shown to be worth of course more than the mine worth by the Hoskold factor. In this sense the Hoskold factor in this particular case is too low by 32% of the amount given in the table.

Commenting on the formula, Mr. K. F. Hoskold writes:—

"The question are to whether the Hoskold method of mine computation is or ought to be based upon the investment of a fixed sum of money for any other period of investment, for a fixed term of years. A 10% investment being deemed to be normally sufficient therefore we find we can pay for a mine the amount that leaves us the usual profit and allows the mine company to the end of the period of the lease. A 10% investment fund, for example, is one that will yield 10 per annum on the sum value of the fund and return the sum invested in 10 years. The sinking fund is to replace the fund to be exhausted by the mining operations."

Take as example Mr. Woodman's case of a mine with an expected life of 10 years, paying an annual dividend of $1000, the investment, the amount invested is $4000, and the sinking fund is to be 4% per annum. The value of Woodman's property for present value of this annual dividend is $5291.37. Out of each year's dividend $1000, one half is the interest at 10% on capital and $500.00 is put into the sinking fund. At the end of the first year the investor will have received the interest on the original capital, $400, and the sinking fund will have accumulated $500. The capital remaining invested is now $4500 and the sinking fund is $500. The interest on the capital is $450 and the sinking fund $500 for the second year. The sum of the sinking fund at the end of the second year is $1000 and the capital remaining invested is $4000. The interest on the capital is $400 and the sinking fund $500 for the third year. The sum of the sinking fund at the end of the third year is $1500 and the capital remaining invested is $3500. The interest on the capital is $350 and the sinking fund $500 for the fourth year. The sum of the sinking fund at the end of the fourth year is $2000 and the capital remaining invested is $3000. The interest on the capital is $300 and the sinking fund $500 for the fifth year. The sum of the sinking fund at the end of the fifth year is $2500 and the capital remaining invested is $2500. The interest on the capital is $250 and the sinking fund $500 for the sixth year. The sum of the sinking fund at the end of the sixth year is $3000 and the capital remaining invested is $2000. The interest on the capital is $200 and the sinking fund $500 for the seventh year. The sum of the sinking fund at the end of the seventh year is $3500 and the capital remaining invested is $1500. The interest on the capital is $150 and the sinking fund $500 for the eighth year. The sum of the sinking fund at the end of the eighth year is $4000 and the capital remaining invested is $1000. The interest on the capital is $100 and the sinking fund $500 for the ninth year. The sum of the sinking fund at the end of the ninth year is $4500 and the capital remaining invested is $500. The interest on the capital is $50 and the sinking fund $500 for the tenth year. The sum of the sinking fund at the end of the tenth year is $5000 and the capital remaining invested is $0. The last column gives the total amount in the sinking fund at the end of each year.

It is unnecessary to discuss whether the sinking company or the investor ought to pay the sinking fund. It cannot be used for any other purpose than to replace the capital invested, and therefore cannot be considered from period to period as used for other purposes until the end of the life of the mine. At the end of the life of the mine the investor in this case will have received $4000 in interest and his capital back, or an average of 10% per annum.

An investor in mining stocks takes more than the ordinary risk because of the larger return on his money if the mine comes up to expectations.

He assumes this risk at the moment of purchasing the shares, before it is certain that the mine will come up to expectations. Would he assume the risk if he knew that, in the event of the mine's fulfilling all expectations, he would only receive a rate of interest which could be had by investing in something much more secure, for instance bonds? He would certainly buy the bonds and avoid the risk.

According to the definition of a 10% investment given above the old method of valuation is not in error.'

Mr. Whitton replied as under:

. . . . 'K. F. Hoffmann states that, according to the definition of a 10% investment (the rate that I assumed in my examples) the Hoskold formula is not in error; but, as stated in my paper, it is not sufficient to define a 10% investment in a wasting asset, such as a mine, as one that will pay the investor 10% per annum on his investment and return him his capital at the end of the period of the investment, for there are not one or two but several ways in which the dividend may be apportioned between interest and amortization of the investment that will fit Mr. Hoffmann's definition. According to the formula employed there is a large difference between the various values that may be thus obtained. Obviously some addition to his definition is required before an exact solution can be reached, and according to my view 10% interest should be paid only on the unreturned capital, and the amount of the unreturned capital is the amount originally invested less the amount in the sinking-fund. . . . . .'

Mr. D. B. Morkill discusses Mr. Whitton's article in the *Mining and Scientific Press*, August 31st. He proposes the solution given by O. Donahue in his 'The Valuation of Mineral Property,' where the latter assumes that the capital is reduced at once by each payment of the redemption fund and that interest is allowed on the outstanding capital only. This formula is, using the same notation.

$$V = d\frac{(1+i)^n - 1}{(1+i)^n i}$$

The present value on these premises for the example given is $6144.58.

Mr. H. D. Pallister, continuing the discussion (*Mining and Scientific Press*, November 23rd), gives the following interesting comparison:

Year.	Hoskold Per cent.	Whitton Per cent.	Morkill Per cent.
1	10	10·00	10·00
2	10	9·48	9·62
3	10	8·89	9·21
4	10	8·22	8·75
5	10	7·45	8·24
6	10	6·58	7·70
7	10	5·58	7·09
8	10	4·45	6·43
9	10	3·16	5·69
10	10	1·68	4·89
	10·00	65·49	77·62

In the table a comparison of the three formulas and tables is given, based on the annual percentage-return to the investor on the amount of his original investment. Hoskold has a constant return of 10%; Whitton decreasing from 10% during the first year, to 1·68% during the last; and Morkill with the interest from the sinking-fund added, decreasing from 10% to 4·89% at the end of the period of ten years.

Summary.—The three formulas are similar in at least a few respects. (1) They all provide for a return of the original amount of the investment at the end of the same period, namely, ten years. (2) They all allow the same rate of interest, *i*, (10%), on the present value of the investment *as interpreted by each*. (3) They all provide for a safe rate of interest, *j*, (4%), on the sinking-fund. Although the Morkill formula does not show this, nevertheless, Morkill uses the interest to pay an increased amount to the investors annually. The three formulas differ in a number of respects. The present value is constant in the Hoskold formula and table, and decreasing in the other two. In the Whitton, the present value is 20% greater than in the Hoskold at the beginning of the period, while the Morkill formula gives a present value 12·5% greater than the Hoskold. The result in the case of Hoskold is an equal annual return to the investor throughout the life of the mine, while in both the other cases the annual return is greater at the beginning of the period, and decreases to a minimum at the end. Finally, the amount placed in the sinking-fund is the same for each year in the Hoskold, while the Whitton and Morkill formulas indicate an increasing amount for each succeeding year." (H. R. A. and G. A. W.)

Abstracts of Patent Applications.

650.18. Ray, C. Newhouse. Comminuting mill. 26.10.18.

This application refers to various internal arrangements for tube mills, providing a series of chambers in the length of the mill with the object of securing stage reduction.

At the end of the first stage chamber, a cylindrical screen made up of bars parallel with the axis is introduced, through which the material which is sufficiently reduced passes into an annular space behind, from which it is lifted by vanes on the division plate and passed through it to the second chamber. A screen plate with vanes is also provided at the final outlet.

The screen with division plate between the two chambers is capable of adjustment in its longitudinal position, so that the relative capacities of the two chambers may be varied as may be required, the internal diameter of the mill being the same throughout.

Changes of Address.

Aymard, Lieut. M., R.F.C., *l/o* Johannesburg; West Lodge, Colchester, England.

Ball, Capt. H. S., R.E., *l/o* Mine School, First Army, France; c/o Standard Bank of South Africa, 10, Clements Lane, London, E.C.

Harris, T. H., *l/o* Robinson G.M. Co.; New Heriot G.M. Co., P.O. Box 10, Cleveland.

Macdonald, F. G., *l/o* Roodepoort; Witpoortje Hotel, Witpoortje.

Prout, W. M., *l/o* Pienaars River: 5 and 6, Chudleigh's Buildings, Eloff Street, Johannesburg.

Stokes, Lt.-Col. R., D.S.O., M.C., *l/o* Controller of Mines, First Army, France; Commander (C.R.E.) North Russian Expeditionary Force, c/o G.P.O., London.

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Vol. XIX FEBRUARY 1919. No. 7.

Proceedings
AT
Ordinary General Meeting, February 16, 1918.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 15th February, 1919, Mr. H. S. Meyer (President) in the chair. There were also present:

29 Members: — Messrs. J. Gray, A. Whitby, H. A. White, H. R. Adam, J. Chilton, C. H. Greathead, J. R. Thurlow, C. Toombs, F. Wartenweiler, G. A. Watermeyer, F. W. Watson, W. R. Dowling, J. E. Thomas (Members of Council), A. S. Allan, H. D. Bell, T. Blandford, J. M. Dixon, P. Friedman, B. J. Hastings, L. D. Hingle, A. King, A. H. Krynauw, Dr. E. T. Mellor, G. Melvill, S. Newton, E. A. Osterloh, J. Thorlund, and T. P. Waites.

11 Associates: — Messrs. J. Boyd, G. Bulman, B. C. Forrest, J. Gibson, J. Innes, S. Lange, L. W. Macer, D. W. Pugh, D. R. Robinson, J. de Villiers, and H. Ward.

10 Visitors, and Fred Rowland, Secretary.

MINUTES.

The Minutes of the Ordinary General Meeting held on the 16th November, 1918, as recorded in the November *Journal*, were confirmed.

ELECTION OF NEW MEMBERS.

Messrs. J. R. Thurlow and A. Whitby were appointed scrutineers. After their scrutiny of the ballot papers the following new members were declared elected:—

DURELL, HAROLD LANCELOT VAVASOUR, Central Mining and Investment Corporation, Ltd., P.O. Box 1169, Johannesburg. Mining Engineer.

READ, HERBERT ALFRED, Rand Mines, Ltd., P.O. Box 1056, Johannesburg. Financial Manager.

TUTT, CHARLES JOHN, P.O. Box 5754, Johannesburg. Mine Manager.

The Secretary notified that the Council had admitted the following as Associates and Student:—

As Associates:

ANDERSON, ROBERT CHARLES, Modder B. G.M. Co., Ltd., P.O. Modderbee. Reduction Foreman.

DALY, WILLIAM EUGENE, B.Sc., P.O. Box 58, Bulawayo, Rhodesia.

EAMES, LUTHER BARNARD, c/o The Dorr Co., 1009, 17th Street, Denver, Colo., U.S.A. Metallurgical Engineer.

SHORT, ARTHUR, Brakpan Mines, Ltd., P.O. Box 3, Brakpan. Assistant Assayer.

As Student:—

HARDING, ELLIS GEORGE, Student, S.A. School of Mines and Technology, P.O. Box 214, Germiston.

GENERAL BUSINESS.

ASSAY SUPPLIES.

Mr. C. Toombs *(Member of Council):* In replying to the discussion on the subject of Assay Supplies, I have to thank the various members of the Society who contributed, especially those who realized that the object of the discussion was to bring forward any novel ideas especially in the utilization of local products in routine assay practice. One cannot compliment the assaying fraternity on the success of the object aimed at, when one considers that out of all the assayers engaged on the Rand in strictly routine gold assaying only one came forward to give his views. One would have thought that patriotism would have prevented this wholesale hiding of "lights under a bushel." One often hears the statement made that an assay office is not the place in which to economise; it certainly should not be a place where money is wasted, and I maintain that the results obtained in an office run under trained control will compare favourably for accuracy and economy with results obtained by rule of thumb methods.

As of old, the use of borax in fluxing is a bone of contention, further complicated now by its whole or partial replacement by fluor spar. I still take up my stand with Mr. White and maintain that the use of borax in routine assaying on the Rand is abused, and is moreover as effete a superstition as the use of bi-carbonate of soda recommended in text books up to quite recent times. I am sure the Council of the Society will be very pleased if some of the stalwarts in its favour will come forward with a paper giving full data to prove that results obtained with borax, are consistently higher than those obtained without.

In connection with fluxing, I would recommend a study of the various silicates of soda to junior assayers, especially the bi-silicate Na_2OSiO_2, and sesqui-silicate $4Na_2O3SiO_2$. Under proper heat conditions in the furnace the former will be found quite fluid and an addition of borax will be found to make little difference. This will serve as a base for any junior to start experimenting from in order to work out a flux for himself, and when he has found one which gives a consistently higher result than all others I advise him to stick to it, if he finds several giving equal accuracy then let him stick to that proving the most economical on prolonged use.

One pleasing point brought out by this discussion was the manufacture of the various acids, chemically pure, by Kynochs', Durban. I have been using their nitric acid now for some time and find it very satisfactory, and quite in accordance with their guarantee.

To-day practically everything requisite for routine gold assaying on the Rand can be locally produced, and I am very pleased to be able to give my testimony as to their excellence.

The President: There is just one little point in Mr. Toombs' able reply that fills me with some apprehension. When he speaks about high results, I cannot quite understand what is meant by it. Can a thing contain more than exists in it? He says the use of borax gives high results. It seems to me that the line of argument there is not quite sound. Does this material give the more correct result, which cannot be too high or too low but must be approximately correct? I just mention that point because it seems to me such a peculiar line of argument.

Mr. C. Toombs: My point is this. Take half-a dozen different fluxes: three of these give very consistently high results and three consistently low results. I take it, the high result is right. We have not put any gold into the sample.

The President: I have only one point to make, and that is, the method of classifying a result; it cannot be too high if the gold exists in the sample.

Mr. C. Toombs: I do not think I have used the expression "too high."

Mr. A. Whitby *(Vice-President):* There is a little point about that which I brought out a good many years ago on which at the time I was rather severely criticised. Divide any sample into portions and pass one portion through 60 mesh, another through 90, and another through 150, and with equal times of fusion progressively higher results will be obtained. That is possibly what Mr. Toombs means; that certain fluxes attack the ore much more easily than do others, because they bring about a condition where complete fusion is arrived at at a lower temperature.

Mr. C. Toombs: Yes, that is what I mean to infer.

VISIT TO NEW MODDERFONTEIN.

Mr. H. A. White *(Vice-President):* I should like to propose a hearty vote of thanks to the directors and management of the New Modderfontein Gold Mining Company for the way in which they entertained us at our last visit there.

This Society has always taken considerable interest in Red Cross work, but I think you will agree with me when I say a more interesting exhibition of First Aid was given on that occasion than we have ever seen in our lives! You will also agree with me that it was an excellent object lesson on the closer working and joint housing of the technical societies.

Mr. A. McArthur Johnston *(Past-President):* I second that.

The motion was carried unanimously.

MEDICAL SCHOOL ON WITWATERSRAND.

Mr. Jas. Gray *(Vice-President):* I desire to propose the following resolution:—

"We, the Members of the Chemical, Metallurgical and Mining Society of South Africa, in ordinary meeting assembled, regret the action of the Government in refusing to sanction the appointment of Professors of Anatomy and Physiology, thereby postponing the extension of the Johannesburg Medical School."

The facts which bring up this resolution are as follows, and I cannot do better than quote a letter which has been sent by the Secretary of the Witwatersrand University

Committee to all their Members of Parliament:—

"In 1917, with the approval of the Minister, courses in Arts, Pure Science and Medicine were started at the School of Mines, the funds therefor having been subscribed by the Chamber of Mines, the Johannesburg Municipality, several of the Reef Municipalities, and a number of other generous subscribers. The Government now recognises the departments then established (Classics, English, Economics, Dutch, French, History, Botany and Zoology) to the extent of contributing towards the salaries of the professors. Owing to war conditions, however, it was at that time found impossible to proceed to the second year's course in Medicine as suitable Professors of Anatomy and Physiology (the subjects of the second year) were not available. . . . ."

The professors of Bacteriology, Pathology and Pharmacology were obtained for the Capetown School of Medicine at that time.

"Recently, however, in view of the altered war conditions, the Council of the South African School of Mines and Technology approached the Minister with regard to the establishment of Chairs of Anatomy and Physiology. The Minister has now refused to recommend to the Governor-General the establishment of a School of Anatomy in connection with the School of Mines in Johannesburg, in terms of the University Act (No. 32 of 1911). Both in 1917 and in 1918 there were thirty first year medical students, who were anxious to proceed to the second year's work in Medicine at the School of Mines, and it is confidently expected that those numbers will be greatly increased now that hostilities have ceased."

There is admittedly a shortage of medical men in South Africa and also in other countries, and the number of students available in Johannesburg, justifies the development of the medical school.

The Johannesburg Hospital is, I believe, the third largest in the world, and further, we have the many mine hospitals, which support the statement that facilities for training in Johannesburg are unique.

It was understood that when the professors of zoology and botany were appointed, they were to be teachers in the medical school, and the Government's action is a distinct breach of faith to these men. In reply to a question in the House of Assembly recently, it was stated that the refusal was entirely due to financial reasons, but it appears much more likely that Capetown eyed with jealousy the rapid advancement of our local school.

I have brought forward this resolution for the purpose of supporting Professor Wilkinson, who is our representative on the Witwatersrand University Committee, and I hope that any action it may take, will result in our obtaining in Johannesburg, a medical school where a complete course of training may be followed.

I have much pleasure in moving the adoption of the resolution.

The President: I should like to have a seconder to this very praiseworthy motion that Mr. Gray has put before you.

Mr. A. Whitby *(Vice-President)* In rising to second the resolution, I wish to endorse the proposer's remarks.

It seems a shame that Johannesburg and the Reef do not receive the consideration from the Government commensurate to the revenue directly and indirectly derived from this community by the State.

Surely, if we are entitled, as Mr. Gray points out, to schools of botany and zoology, the very important subjects of anatomy and physiology should be included. Besides, there are many people who cannot afford to send their sons to Capetown for medical training and would, if they could, probably send them to England in preference, and not add much to the cost.

There is another point arising out of this question, and that is the exploiting of South African drugs. This requires collaboration between chemist, botanist and medical men, and where else could the utility of these drugs be better proved than in a school of medicine in conjunction with the great hospital and the Institute of Medical Research already established. I have therefore great pleasure in seconding Mr. Gray's resolution.

Mr. F. W. Watson *(Member of Council)* supported the resolution.

The President: It seems to me it is one that is permitted to the Society as part of its objects; that is, to promote science in every sense and degree, and we feel hurt that a genuine attempt on behalf of Johannesburg to promote this school of medicine has not been exactly treated in the way that we had hoped. It is not for us here to discuss the Government particularly, but, at the same time, we thought that our voice should be heard in support of our member, Professor Wilkinson, who represents us on the Witwatersrand University Committee. Unless there is any other gentleman who wishes to say anything, I should like to put Mr. Gray's motion to the meeting.

The resolution was then put, and agreed to unanimously.

ANCIENT TIN MINES OF THE TRANSVAAL.

By Max Baumann (Member).

Introductory.—Although a great deal has been written upon the ancient mines of Rhodesia, very little has been published on the subject of the ancient workings in the Transvaal. Mr. T. G. Trevor, Inspector of Mines, Pretoria, read a paper on this subject before this Society some seven years ago. Since that date several fresh facts have come to light, and it is hoped that the discussion on this paper will help to elucidate the very interesting mystery as to who these ancient miners were and the period when they wrought here.

Geological.—As no ancient workings have been discovered in the granite tin area, *i.e.*, at Zaaiplaats, Groenfontein, etc., the writer intends confining himself to the Rooiberg-Leeuwpoort area (see Map. Fig. 1), which is situated in the Waterberg District, some 40 miles west of the Pretoria-Pietersburg railway.

The cassiterite occurs in well defined lodes, varying very greatly in strike, dip, thickness and tin contents, in the quartzite and sandstone of the Lower Waterberg Series. The principal associated mineral is tourmaline, and sometimes a fair quantity of iron pyrite. More rare is the occurrence of either copper or arsenical pyrite, and infrequently there is a small quantity of wolframite, scheelite or galena. The gangue minerals are quartz, calcite and siderite, and occasionally fluorite. In addition to the lodes proper, ore occurs in pockets, well defined pipes and bedding planes (flats) formed by metasomatic replacement of the silica in the sandstone by cassiterite and the associated minerals mentioned above. These non-lode ore-bodies, sometimes called "supplementary fillings," like the lodes themselves, vary greatly in shape and extent, some of the horizontal flats have been 6 to 7 ft. in thickness, while pipes of small cross-sectional area have been followed for more than 100 ft. off the lode. It is a point of interest that very few of these "supplementary fillings" have been found in the hanging wall of the lode, in nearly every case they start off the footwall and the great majority of them are high in tin contents. This explains perhaps why so much of the ancient work had been done on these bodies and not on the lodes proper.

Prospecting.—The Map, Fig. 1, shows the area where the ancients mined or prospected; on every farm there are traces of one sort or another of their bygone industry. Hardly a lode of any importance has been worked by moderns on which the ancients have not been down in one or more places. Where modern work has shown the richest lodes, or where these cross one another most thickly, there the ancients have been most active. One area at Rooiberg, about 40 acres in extent, is thickly pitted for a length of two-thirds of a mile and an average breadth of 600 ft. by a succession of overgrown shallow depressions interspersed with small ancient waste dumps. Wherever these dumps have been cut through for prospecting purposes, rarely, if ever, has any tin-bearing rock been found. This bears out the observation of other writers upon the extremely clean manner in which the ancients sorted, and shows that they must have been pretty good mineralogists to be able to distinguish tin ore from tin poor or tin free tourmaline rock—rock which often requires modern methods of assaying to prove its valuelessness.

Mining.—Where in the course of their prospecting the ancients came upon rich ore they followed it down until beaten by water or the rock became too hard. Where ore occurred in pockets, flats or pipes it was followed and taken out with a cleanness which is truly astonishing. This is well illustrated in figure 2 (p. 123), which shows an ancient working recently opened up at Rooiberg, consisting of a stope on the "H" Lode and two pipes in the footwall of the lode. The cross section (X.Y., p. 122) shows the pipes to be roughly elliptical in shape and to run in approximately horizontally (see sections on C.D. and E.F.). The working was struck by a modern drive, but was entered by the ancients from a narrow pipe off the lode. The lode was lenticular in cross section, and was stoped out to a maximum width of 6 ft. to 7 ft. The south branch pipe is very low and the walls have a corrugated appearance; they have been chipped clean and smooth, showing in some cases no mineral at all, in others a mere paper thickness of ore at the contact of sandstone and ore. The pocket was so low and narrow that at the point C. the ancient miners had evidently to lie quite prone with back and

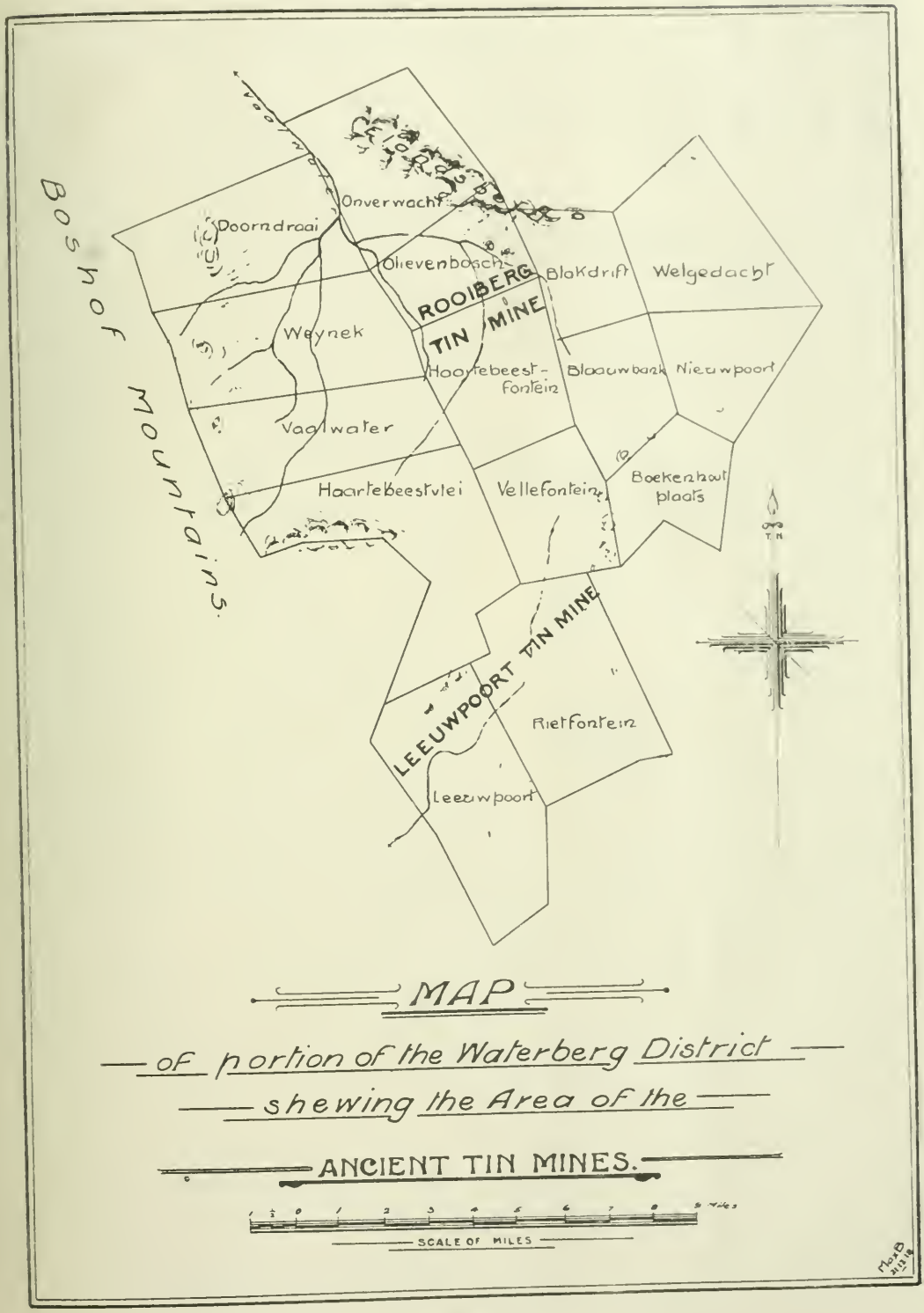

Boshof Mountains.
Vaal
Onverwacht
Doorndraai
Olievenbosch
ROOIBERG TIN MINE
Blokdrift
Welgedacht
Weynek
Hoorlebeest-fontein
Blaauwbank
Nieuwpoort
Vaalwater
Hoorlebeestvlei
Vellefontein
Boekenhoutplaats
T.N.
LEEUWPOORT TIN MINE
Rietfontein
Leeuwpoort
MAP
of portion of the Waterberg District
shewing the Area of the
ANCIENT TIN MINES.
SCALE OF MILES

FIG. 1.

sides touching the wall. Again, at the three root pockets at P. the miner could not get his head and shoulders into the hole. The biggest hole is 24 in. high, and he had therefore to stand in a crouching position and chip with his arms at full stretch above him, while the chippings fell on his head. The

Cross Section on Line C D (Fig 2)

Cross Section on Line E F. (Fig 2)

Cross Section on Line X.Y. (Fig 2)

northern pocket was wider, and was remarkable for the large number of stone hammers (some 120) found in it. At the end E. a face of rich ore had been left standing. This was a roughly elliptical horizontal pipe 48in. x 24in., consisting of a central core of soft tin-poor tourmaline surrounded by a concentric ring of medium grade tin ore, and this again surrounded by an outside ring of very rich ore. Generally speaking, the ancients mined so clean and left so little behind them that this occurrence of ore left in place is very interesting. The old miners must have been disturbed and left suddenly—either a raid occurred or the entrance may have fallen in—otherwise they would not have abandoned such a large number of stone hammers, nor would they have left the working unfilled and a face of good ore behind for their modern successors to continue, who have taken from there some 70 tons of ore going 7 metallic tin.

Breaking.—The ore was broken or chipped away with hammer and gad. The gads were of steel, roughly rectangular in section $1\frac{1}{4}$ in. × $\frac{3}{4}$ in. and 12 in. to 18 in. over all, made in one continuous taper from the head to a fine point, Fig. 4 (5). The metal was of extremely fine quality, being a mild steel of exceptional purity equal in quality to the best Swedish iron. The following is an analysis:—

Silicon	0·17%
Sulphur	0·01%
Phosphorus	Trace
Manganese	Nil
Combined Carbon ...	0·35% (approx.)

The hammers, Fig. 4 (13) were of stone and are roughly spherical in shape, in diameter from 3 in. to 5 in., and weigh between 3 lb. and 6 lb. They are the hard unweathered round lumps which remain as a result of the spheroidal weathering of diabase. The majority of the hammers probably came from the farm Onverwacht (see Map. Fig. 1), where a diabase dike outcrops. A few of the hammers are of hard felsite, of which many small dikes traverse the area under discussion. The hammers appear to have been held in the hand and no handle was used. Many hammers have had a deep concentric groove cut round a mid-circumference due to the constant tapping on the head of the gad. That fairly effective work could be done with a stone hammer was shown by a hammer boy at Rooiberg who collared and drilled, with a set of modern steel drills and a handleless stone hammer, a hole 36 in. deep in ground in which over the same drilling period, but using a 4 lb. hammer, he could put in a 54 in. hole.

Where the ground was too hard to break with hammer and gad, the method of firesetting was employed, a method which was used as recently as 40 years ago in Norway. On the "H" lode at Rooiberg a pile of wood ready for fire setting was found in the face of a flat elongated old working. The wood was about 4 ft. long and 4 in. to 5 in. in diameter, stacked near the face in a roughly conical pile; it had been such a length of time in the air-tight working that when touched it crumbled to an impalpable powder. In addition to the small hammers, occasionally a very large hammer or muller is met with. These were used either to break up large lumps, the result of firesetting, or to grind to a powder the broken ore before

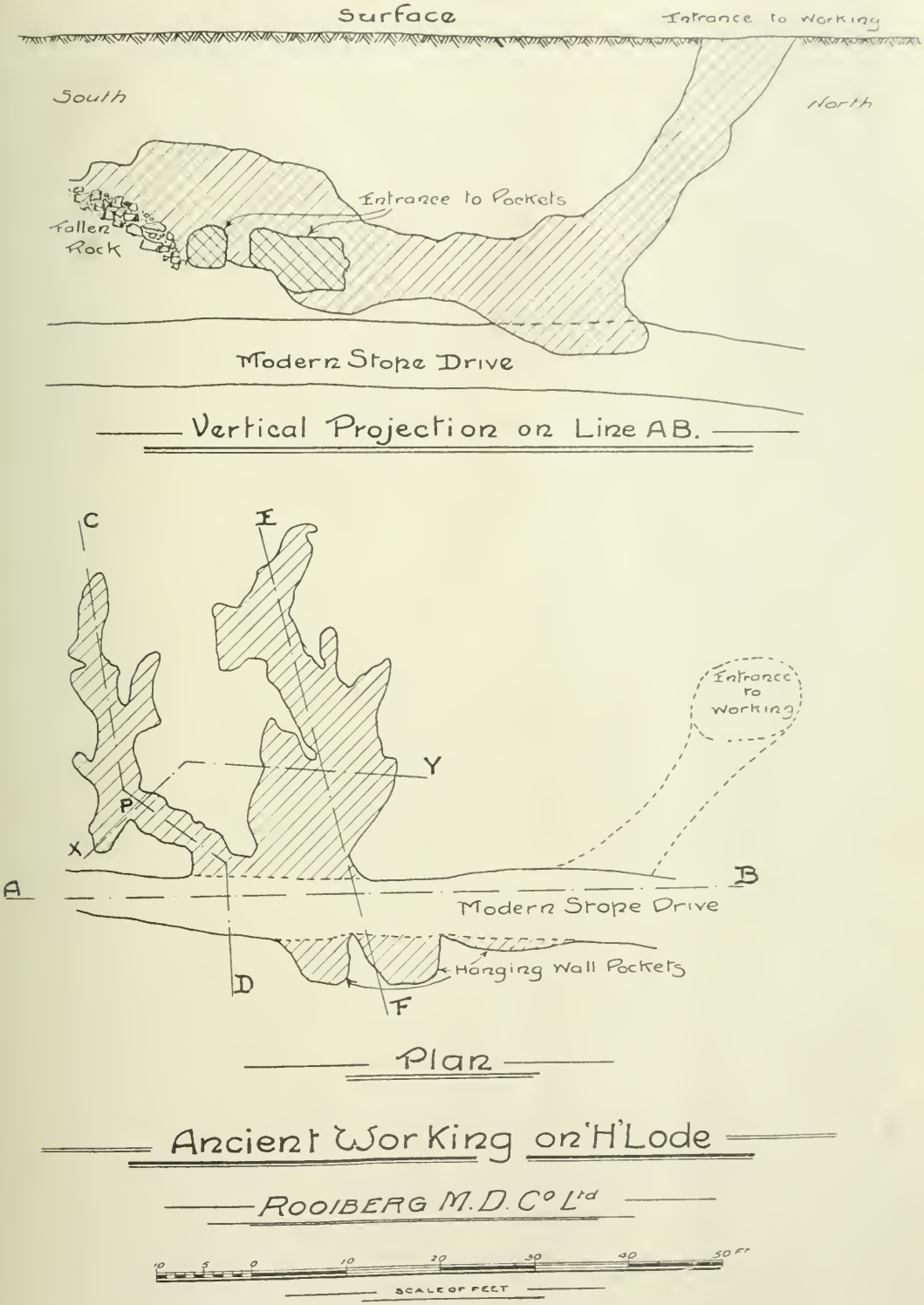

Surface
Entrance to Working
South
North
Entrance to Pockets
Fallen Rock
Modern Stope Drive
Vertical Projection on Line AB.
C
E
Entrance to Working
Y
P
X
A
B
Modern Stope Drive
Hanging Wall Pockets
D
F
Plan
Ancient Working on 'H' Lode
ROOIBERG M.D. Co Ltd
10 5 0 10 20 30 40 50 Ft
SCALE OF FEET

FIG. 2.

transport to the surface. One such stone Fig. 4 (11), was quite smooth, roughly oval in shape, and measured 9 in. in diameter at a mid-section, 14 in. across its longest axis and weighed 70 lb. It was found lying in one of several artificial dish-shaped depressions which covered the floor of a horizontal pocket, where grinding had evidently been done underground.

Most of the ancient workings were filled in before being abandoned. This is also a Rhodesian experience, but the reason for doing so is hard to conceive; most likely the reason was a superstitious-cum-religious one. The other explanation advanced by some, *i.e.*, the filling-up to hide the existence of a mine, seems to the writer out of court in an area like this of Rooiberg, where the small mines were as thick as diggers' claims on the river diggings; more particularly as no working was filled up until (except in a few cases) it had been scraped bare of all payable ore by the ancients. It is more particularly at Leeuwpoort where the workings have been most carefully filled in with a mixture of rubble, broken waste and surface soil. The remarkable feature at Leeuwpoort is that the ancients have left no other records of any kind. Not a gad nor a hammer has yet been found in any working, nor are there any traces at surface of smelting operations. The principal old workings there are over what is called the "H.G." section, and it would almost appear as if the ancients cleaned up everything they could and moved away with all their impedimenta, probably to Rooiberg.

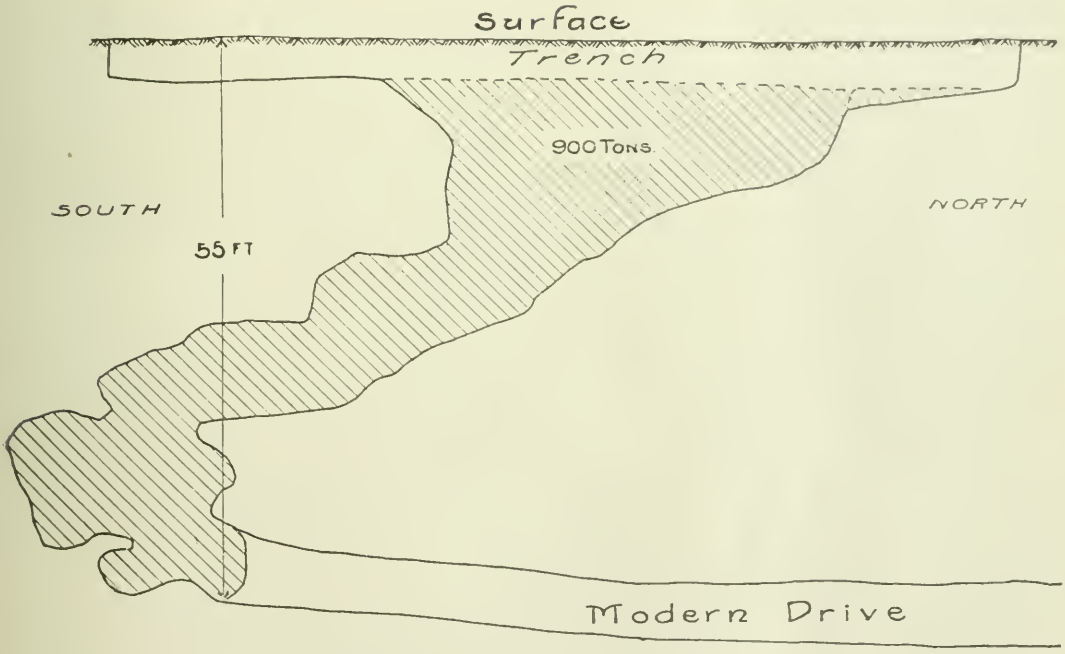
None of the old workings at Leeuwpoort is deeper than 40 ft., and they have been broken into at several points from the modern chambers below. There is no apparent reason why the ancients should have stopped at that depth. The tin is found here in a very wide kaolinized body, which is quite soft. Nor could water have been the cause of abandonment for the present mine 300 ft. deep can be kept dry with a skip only. There is every evidence that the ancients must have mined a considerable tonnage apart from the fact that the Leeuwpoort Company have extracted 80,000 tons of ore between the ancients' lowest limit and the modern 100 ft. level.

As a variant of the total fill-in method was one used on the Empire lode at Rooiberg. Here the lower section of a stope was found open; about half way up the stope, which was narrow, stull pieces 18 in. to 24 in. long were wedged between foot and hanging wall, these were lagged over with rough bush timber and the stope filled in on top of the lagging with the usual mixture of rubble, broken waste and sand. Yet another well known mining practice was followed at Weynek (see map, Fig. 1). Here the tin occurs in soft clayey interbedded lodes dipping 10 deg. west, and varying in thickness from a few inches up to 4 ft. The majority of the stopes do not go down more than 50 ft., but the principal one followed the lode to a depth of 120 ft. on the dip. The stope had been started as an open cast with a width of about 20 ft. along the strike, it then bellied out below to a maximum width of 50 ft. on the strike coming down at the bottom to 15 ft. The average width of the stope was 30 in., but at places this narrowed down to 10 in. (actually measured). At that flat dip and narrow width no full-sized man could work, and the actual ore breaking must have been done by small boys or an undersized race like the Bushmen. This stope is of particular interest from the fact that a number of pillars were left in it, not as might have been supposed to support the hanging, but simply because the value had gone out of the ore. In addition to following the ore down from the surface by small shafts or opencasts there is an instance at Weynek of a working having been entered by an adit at right angles to the strike of the lode.

The longest continuous ancient working is that on the South End lode at Rooiberg. Here the ancients stripped the outcrop from the surface to a depth varying from 15 ft. to 27 ft. over a length of 620 ft. on the strike. The average width on the top of the cleaned out workings was 20 ft., which narrowed down considerably at the bottom. Modern work below that of the ancients has shown the existence of a narrow but rich lode. 450 ft. of sampled development gave an average of 11·4% metallic tin over 7 in.; over a stoping width of 30 in., and at the present price of tin (£220), this is equivalent to over 80s. per ton mined. The probability is that the ore at surface was very much richer, and judging by the width of the workings, much wider. Much of the stoped out lode had been filled in as usual. There was evidence of the filling having been done in two distinct periods. At one spot, where the working was being bottomed and the filling had been cut through from top

to bottom, it was observed that there was a layer of several feet in thickness of sharp broken waste and rubble at the bottom. This was covered by a layer about 2 ft. thick of surface sand, above this was another layer of waste and rubble, and covering this to normal ground level was a top layer of surface sand. The intermediate sand layer was not uniform throughout but was made up of a succession of laminae of light and dark coloured sand, each lamina probably representing the washings in over one rainy season, and the number of laminae indicating a considerable number of years occupied by the washing in process. The working clearly showed an early period of mining, then a long interval of abandonment followed by a second period of mining and final abandonment. From the appearance of some of the relics found here, some of the work must have been of quite recent date. On a ledge, and hidden away after the manner of the modern native, was found a gad, stone hammer, knobkerrie (Fig. 4 (7), and adze with handle (Fig. 4 (8). The adze was 12 in. long by 5 in. cutting edge, which was set at right angles to the plane of the handle and ended in a tapered shank which fitted into a tapered hole in the handle—a method of fastening which to-day is still being used for native axes.

Lighting.—The question of underground illumination has quite an important bearing on the subject of the age of these workings. The working shown in Fig 3 is open to day light, and the afternoon sun can shine right into the toe of the stope; it was therefore probably worked throughout without any artificial illumination. In the case of the



Vertical Projection of Ancient Working on 'H' Lode

ROOIBERG M D Co. Ltd

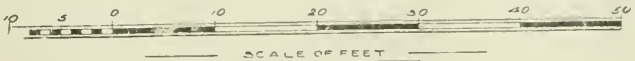


Fig. 3.

narrow and low pockets in Fig 2 however, it was impossible for the old miners to have done the careful and clean work which they did without some kind of artificial light. Now, Dr. Theal points out that the Bantu have no lamps, and R. N. Hall infers from this that the ancient miners of Rhodesia could not have been Bantu. But, on the other hand, no remains of anything resembling a lamp has been found locally. It is possible that the darker workings were mined in earlier times by a people who were acquainted with an artificial light, while workings such as illustrated in Fig. 3 were worked in more recent times. This working is very extensive and unlike most other workings, was never filled in by the old workers. As it lies in the bed of a storm water course it became filled up with clean water-borne sand probably in the space of a very few years. It was holed into by chance at its deepest point 55 ft. below the surface by a modern drive. The working was cleaned out in the hope of finding ore left in place, but with disappointing results. At the bottom a tree was found 6 in. in diameter at base and about 14 ft. long with the branches hacked off about a foot from the stem, and which had evidently been used as a primitive ladder. The wood is said to be, what is locally called, Olievenhout, and was in a very good state of preservation. Further, about 50 ft. down an earthenware pot (Fig. 4 (10) was found, which was still soot encrusted. It is almost spherical in shape, 7 in. in diameter and 5 in. deep, of fairly coarse texture and resembles in all respects a modern Basuto cooking pot.

Transport.—The broken ore was probably carried to the surface in baskets or grass bags, the material of which is so perishable that no remains have been found. It is possible too, since a good many earthenware pots have been found, that these were also used for transport. The largest pot discovered (Fig. 4 (9) was almost spherical in shape, 16 in. diameter and 14 in. deep and holding about 7 gallons. Mention has already been made of the discovery of a crude ladder, and in an old working on the Empire lode at Rooiberg a number of steps or foot-holds can be seen which have been cut out from top to bottom of the soft footwall of the working, dipping at 75 deg.

Metallurgical.—It has already been mentioned that some of the ore was probably ground to powder underground, though the greater quantity was reduced to that state at surface, as is proved by the large number of mullers (Fig. 4 (11) and grinding stones (Fig. 4 (12) found everywhere. In the course of trenching, broken ore has frequently been found a few feet below the surface, evidently having been dropped in the course of transportation. As these odd pieces have almost invariably been of extreme richness one is forced to the conclusion that the ancients only worked ore of high tin contents.

The ore, after being reduced to powder, was washed either in flat dishes of earthenware, closely woven baskets or perhaps by some method of calabashing, as in Nigeria. The spruit running through the Rooiberg property was probably the principal scene of these washing operations, but in one case they appear to have used an old working as a slime pit. This was an ancient open-cast on the Empire lode at Rooiberg roughly rectangular in shape, 45 ft. long by 20 ft. wide at top, narrowing down to 4 ft. at a depth of 15 ft. The material in this pit was unmistakably slime tailing being much finer than the surrounding reddish surface sand, and was arranged in alternating light and dark layers which dipped at 15 deg. The slime assayed 1·2% metallic tin, and some 200 tons were excavated and treated in the modern mill.

All the ore mined by the ancients came from near the surface, and would contain little or no sulphide. By panning, the lighter tourmaline, gangue, carbonates of copper and oxides of iron would be easily removed leaving a concentrate of perhaps very near 70% metallic tin. The concentrate was probably not calcined, for an ingot of bronze found contained 2% of arsenic while several tin ingots discovered were very impure.

Smelting.—The principal centre of smelting appears to have been an outlier to the Elandsberg Range, known as Smelters Kop (Fig 5). The kop is a steep, fairly flat-topped hill about 1½ miles from the Rooiberg mine. The edge of the plateau on top is guarded by the usual rough Basuto stone schanzes, such as may be found anywhere in the Transvaal. Scattered over the top are many small slag heaps—some of the slag containing quite considerable sized beads of tin—and innumerable broken pieces of coarse earthenware. These are the remains of crucibles and tuyères used by

the ancients. The portion of a tuyère shown in Fig. 4 (4) is cylindrical, external diameter 3 in. and internal diameter 1½ in.

It is much to be deplored that in the early days of modern mining here, the value of Smelters Kop as a record of the past was not recognized and that no attempt was made to properly investigate the smelting site. A decade of picnicking has done much to obliterate any evidence which could have been scientifically recorded. It is impossible therefore to reconstruct their smelting furnaces, which were probably blast furnaces similar to the primitive kind formerly used in the Straits by Chinese. The blast may have been produced after the Bantu manner with two skin sacks, or after the Chinese manner with a hollowed-out tree, with piston and long piston rod.

Apart from Smelters Kop, numerous smelting sites with their remains of slag and broken nozzles are to be found on Olievenbosch, Haartebeestfontein, Weynek and Blaauwbank. On the latter farm a most interesting ancient furnace bottom was discovered. It was a circular ring of hard baked clay, about 2 ft. in diameter, and stood up about 1½ in. above the surrounding veld. In the sand on the outside of it was found an unformed lump or ingot of bronze (Fig. 4 (3)), evidently the result of an overflow of molten metal through a crack in the bottom of the furnace. The composition of the ingot was as follows:—

		Per cent.
Cu	about	80
Fe and Al	,,	5
Ni	,,	3
Sn	,,	7
As	,,	2
Gangue	,,	3

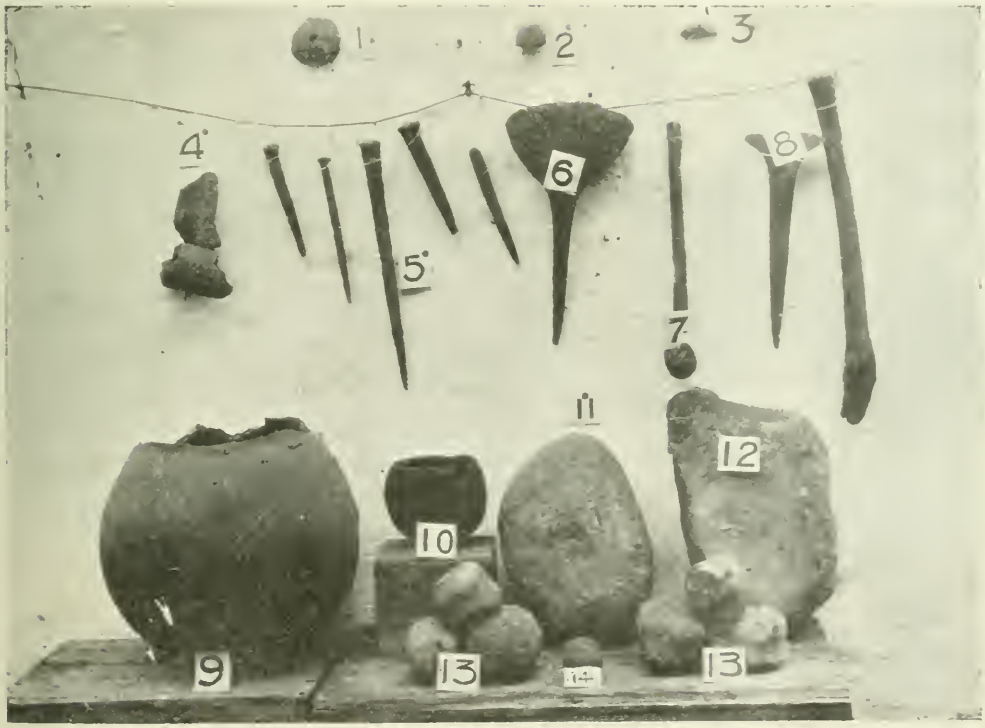


FIG. 4.

(1).—Tin Ingot, Camp Workings, Rooiberg.
(2).—Portion of Copper Ingot, Smelters' Kop.
(3).—Bronze Ingot, Blaauwbank.
(4).—Tuyere.
(5).—Gads.
(6).—Hoe.
(7).—Knobkerrie.
(8).—Adze, with Handle.
(9) and (10).—Pots.
(11) and (12).—Top and Bottom Grinding Stones.
(13).—Stone Hammers.
(14).—Stone Ball.

The presence of arsenic may be due to non-calcination of the tin concentrate used; but the nickel content is rather remarkable. It is interesting to note that this farm Bhaanwbank, where the ingot was found, is one of the few places in South Africa where nickel is known to occur. On the western boundary of Haartebeestfontein small heaps of slag have recently been discovered containing 30 to 35 of oxide of tungsten and 2½ of metallic tin.

Of the remains discovered, mention has already been made of gads, hammers, adzes, pots, etc.

The following further finds have been recorded:—

human shin bones; teeth of some large quadruped, probably quagga, and numerous pieces of tortoiseshell, chipped arrow heads of hard felsite and digging stones have also been found, but only in the sand overburden, and are almost certainly of Bushman origin.

One more evidence of the ancient occupation of this district is an ancient road (see Fig. 5), which starts from the nek, joining Smelters Kop to the Elandsberg and climbs the latter in a northerly direction and at the summit turns east, is lost, or at any rate, has not been further traced. It has been cut out of the side of the hill, and the excavated material filled in on the

FIG. 5.—Smelters' Kop with Elandsberg Range, showing Ancient Road in background.

A couple of ingots of tin (Fig. 4 (1) from the Camp workings, Rooiberg, containing 95·3 metallic tin. An ingot of copper (Fig. 4 (2), found on Smelters Kop (analysis not available). A stone ball (Fig. 4 (14) almost truly spherical, diameter 2½ in. with a circumferential groove ½ in. wide by 1/16th in. deep. Object or use of same is not known. A hoe (badza) (Fig. 4 (6) similar to present day hoes of native manufacture. Bones, supposed to be

down hill edge of the road, and it is wide enough to take a wheeled vehicle. The road was not made by any Bantu, for no Kafir has ever been known to pick a stone out of his path—he will either step over or go round it—and he never has been known to build a path, besides it is much too broad for a native road and apparently leads nowhere. From its state of dilapidation and the vegetation growing in it, it must be very old. It has not been made by the

Voortrekkers nor by any other Boers, for no Boer would climb over a hill when he could go on the flat, round either end of the range as can be easily done. It is, therefore, of earlier age than either Bantu or Boer.

Smelters Kop was a sort of Acropolis, overlooking the Rooiberg Valley—well situated for defence—a place of refuge during times of battle and raids by other tribes. The road may therefore have been built with the object of insuring the safety of travellers—perhaps heavily laden with ingots—in an easterly direction towards the coast. The road is so exposed that no raiders could approach the road unseen and ambush the travellers.

Historical.—Who were the ancient miners, and when did they work here? The presence of underground timber in a very good state of preservation, the comparatively small size of the trees growing in some of the large workings, and the finds of crude earthenware pots and implements pointing to a race resembling and no further advanced than present-day Basutos, all tend to show that some of the workings are of very recent date. Confirmation of this could be deduced from the following:—

In 1723 Jan v. d. Capelle, an official of the Dutch East India Company at Delagoa Bay, reported to the Governor and Council of the Policy at the Cape* (translation). "At the end of the year just passed natives have been at La Goa from the countries "Paraotte" and "Machicosje," who not only brought copper but also tin for purposes of barter; the copper was of very fine colour; the tin was of medium good colour, but somewhat brittle and light as may be seen from two samples of staves (bars or ingots); one of these is much harder than the other, as would happen if remelted. They state that the tin was found on the banks of a river in the country "Machicosje," is gathered in baskets, cleaned of sand and then smelted to bars for the purpose of barter. All the inland dwellers use this tin (also such as they buy from us), which they alloy with copper for the purpose of making necklets and bracelets. That is, no doubt, the reason why their ornaments have such a high polish and are more pliable than those of the Company."

Nine years later this same van de Capelle reported to the Cape that he had purchased 56 bars of tin from natives at Delagoa.

* See Theal, "Yellow and Dark-skinned People," p. 241.

Now, Rooiberg is only 260 miles due west of Delagoa Bay, and it is quite a fair inference to assume that these bars came from Rooiberg or its neighbourhood. Dr. Moffat mentions that as late as 1826 he came across a Mchunutsi copper smith near the Molopo who could smelt bronze, and with a draw plate drew his own copper or bronze wires for making bracelets. All this would point to the very modern date of the workings under discussion by people of Bantu stock, either Basuto or Bapedi.

A careful estimate—though only an approximation of course—shows that 18,000 tons of ore were taken from the Rooiberg area alone. We know from the small lots of broken ore occasionally found that the old workers only smelted ore high in tin contents. Their tailings went over 1 metallic tin, and their average recovery was probably not less than 5 metallic tin. 18,000 tons at 5 metallic tin would give a recovery of 900 tons or, say in round figures, 1,000 tons of metal. Judging by analogy, it is fair to assume that from Weynek, Leeuwpoort, etc., a further 1,000 tons was recovered, or an output of 2,000 tons from this whole area. The great majority of this would be turned into bronze. Assuming that the average alloy had the tin contents of the locally found bronze, *i.e.*, 7 metallic tin, the 2,000 tons of tin expressed as bronze would amount to, roughly, 30,000 tons. What became of this 60,000,000 lb. of bronze? The Bantu in the 1,000 years since they crossed the Zambesi could not have used up that quantity for bracelets and necklets only, that is quite out of the question.

We are, therefore, forced to conclude that the mining, though some of it is recent, extended over a very much longer period than 1,000 years, and that a large portion of the bronze was not absorbed by South Africa, but was exported. There must therefore have been some remote period, when these mines were opened up and the product smelted and utilized by an ancient civilized race of traders. In fact we come to the point of correlating the ancient tin miners with the ancient gold miners of Rhodesia. The writer is indebted to the works of Theal and R. N. Hall for the following short summary of the main facts observed by these and other authorities.

The native races of South Africa can be divided into three great groups, Bushmen, Hottentots and Bantu. The Bushmen

were the aboriginal inhabitants of South Africa. They were nomads, in the lowest scale of civilization, and did not know the use of iron, copper or tin. The Hottentots migrated across Africa in a S.W. direction, crossed the Cunene into what was German South-West Africa and stuck to a comparatively narrow strip round the west and south coast of South Africa till they reached Pondoland, where they came in contact with the stronger and more war-like Bantu, and their progress stopped, nor did they penetrate inland. The Bushmen and Hottentots are therefore excluded from any further consideration in this matter.

The Bantu crossed the Zambesi some time about the year 700 or 800 A.D. The first authentic record of them is by Massoude, an Arab historian of some note, who visited the Mozambique coast in the year 915 A.D. He states that the Bantu were then as far south as Cape Corrientes (north of Delagoa). He also described the coast of Sofala, and refers to the ancient long established trade between the Arabs and the east coast of Africa in gold, amber and ivory, which had been exported to Arabia, India and China. In 1505 the Portuguese settled at Sofala. From 915 to 1505 there are numerous Arab, and from 1505 to 1750 numerous Portuguese records which bring out the following points.

The Arabs did not penetrate far inland, and did not mine for gold. The Portuguese did not mine for gold, but went into the interior in search of slaves. What gold was brought to the coast by natives during this period was alluvial gold, and only in very small quantities. Both Arab and Portuguese records lay stress on the fact that the natives had no gold ornaments and placed no value on gold, whereas copper and bronze ornaments were highly esteemed by them.

The Hinterland of Sofala, the Rhodesia of to-day, has been occupied for over 1,000 years by the Makaranga, a Bantu tribe showing strong traces of Semitic influence. They were a pastoral people, had no use for gold and, except for a little alluvial washing, did no mining of any sort. It is generally accepted that in pre-Koranic days, *i.e.*, before the year 600 A.D. a Semitic people who probably came from Southern Arabia intruded into Rhodesia. They are supposed to have come in up the Sabi River. These intruders were skilful miners, keen prospectors, clever metallurgists and masons of no mean order. They were the originators of the deep rock mines in Rhodesia, and the builders of the many ruins scattered about the country of which Great Zimbabwe is the outstanding example. Hall shows that there are several of these ruins (unexamined) in the Transvaal between the Limpopo and the Letaba, and Mr. Trevor informs me that quite recently a square built ruin with tiled floor has been found in Sekukuniland.

Theal states that the Bantu had no knowledge of bronze, and he is supported by Trevor, who says that there is no record of any native race south of Benin and the Gold Coast being acquainted with bronze or tin. This general statement must however, be modified for it has been shown that bronze was smelted locally, and there is Jan van de Capelle's statement, quoted above, that at the beginning of the 18th century the natives were known to have alloyed tin and copper to make bronze ornaments. There must have been a demand therefore for bronze by at least a small circle of natives and to manufacture which some of the local old tin mines were worked up to anyway 200 years ago. What could this demand have been? 1,000 lb. of bronze containing 7% metallic tin is equivalent to roughly one ton of tin ore giving a 3% metallic tin recovery. Take only one of the more recent workings, such as that shown in Fig. 3, from which 900 tons of ore has been taken. With an output of one ton per annum it may have taken 900 years to exhaust this one mine, thus putting the start of the mine at or about the time the Bantu crossed the Zambesi.

How reconcile the evident antiquity with the comparative modernity of some of the workings? The writer would advance the following theory:—The original tin miners were contemporaries of the ancient gold miners of Rhodesia; that is, they were contemporaneous in a wide sense not over a range of a few years or even a few decades, but they were the same people and coming south prospecting for gold, they struck and worked the copper deposits at Palabora and Messina and the tin deposits in the Rooiberg-Leeuwpoort area and smelted both to bronze, which was exported by them. When the intruders left South Africa they left behind them workmen, who had been taught mining and metallurgy of gold, copper and tin. Some of these workmen may have been Bantu, others were certainly imported labourers from Western Asia who probably became incorporated with the

Bantu. Now the knowledge of gold mining and recovery would soon die out for the records show that in historical times, *i.e.*, since 915 A.D., the natives placed no value on gold. There was, however, at all times a keen demand for copper, bronze and consequently tin for the making of ornaments. The knowledge of mining and metallurgy of tin would therefore continue amongst the natives and would be handed down traditionally from father to son in certain families. Although the bulk of the tin was probably removed in pre-historic times, sporadic mining was persisted in until quite recent times. This theory of the writer would therefore account for the large quantity of tin mined, and yet explain why evidences of such recent mining are met with.

In conclusion, the writer has to thank the managements of the Rooiberg and Leeuwpoort mines for permission to make use of data and drawings, etc., and for the notes received from local observers interested in this subject.

Bibliography.—

G. McC. Theal: "The Yellow and Dark-Skinned People of Africa, South of the Zambesi."

R. N. Hall: "Pre-Historic Rhodesia."

T. G. Trevor: "Some Observations on Ancient Mine Workings in the Transvaal. *C M. and M. Journal*, January-October, 1912.

The President: I am sure the Society must feel extremely gratified in having before it a paper of this description, which shows great technical care and appreciation of the ethnological features that have been left here by the ancient miners of the old days. I do not propose to discuss it at this stage, but, at the same time, I may refer to one or two points that struck me while the paper was being read. The author seems puzzled by the fact that the ancient worker tries to conceal all traces of his work. That, to me, does not appear so extraordinary. It is customary all over South Africa where ancient workings have been found to find great care exhibited on the part of the ancients to hide their tracks. The author mentioned just now, for example, that Leeuwpoort had extracted 80,000 tons of ore from practically immediately below the surface. Whether the ancients had any inkling of this, it is very difficult to say; but it looks very much as if they smelt something or other; they had a good reason for hiding their tracks, as I say. The point the author makes about the analysis of the bronze showing 3 nickel and the fact that there has been no subsequent exploitation of nickel in that district is of considerable interest.

He is also to be very much congratulated for taking the trouble to bring down for exhibition this collection of instruments and implements which he has found and which you may, I think, call an original find on his part; that is to say, he has searched them all out himself and traced very fairly their possible use. He pointed out what he calls a hoe, which, to me, looks like a very fair attempt at a primitive shovel.

Another point of interest that appealed to me was his mention of fire-setting. To the miner who has read his historical text books, fire setting has always been known as one of the first methods of breaking ground, and in the case of fire setting in Norway that he mentions, I have had the privilege of seeing the workings exploited by this method. Although they are remarkable, they must have been very similar to the type of mining he describes here, in that the principle of fire setting was to break away the ground; they heaped up piles of firewood—lit a large fire and then came in later and quenched both the fire and the heated rock. Whether they had gas masks or not in those days I do not know; they did, however, go in to the face with gads and trimmed the sides of the workings, because the sides of the tunnels that are known as having been driven by fire setting were extremely smooth; the time and care that must have been taken to trim these workings is difficult for us moderns to understand.

The connection between bronze and tin naturally brings one to the conclusion that there must have been some close connection with the ancient workings that are familiar to many of you in the Palabora and Messina Districts, and it is probable that these places were the source of the copper that was used, which must also have been brought from some locality which was no further from Delagoa Bay than Rooiberg. I must confess my ignorance, although I have heard a great deal from men in that part of the world about instruments and old workings in those districts I have never been fortunate enough to examine them. I suggest, however, that there must have been some very close connection.

There is only one other point I should like to mention, and that is, in the course of the author's theories as to the type of people who were engaged in this work, he mentions that the people who worked in those districts were of semitic origin, and had no interest whatsoever in or liking for gold. Of course, this is a little bit difficult for the modern man to understand: but there may have been a very good reason for it in those days.

Dr. E. T. Mellor *(Member):* I should very much like to second the vote of thanks proposed to the author for his extremely interesting paper. It has often occurred to me that men who are working for any considerable time in outside districts have very excellent opportunities of writing papers such as the author has read to-night; but I am afraid these opportunities are not very often taken. I think sometimes the writer gets half way, becomes discouraged, and does not go further.

I think, therefore, it is extremely satisfactory to listen to a paper like the author's, because he has carried it out to very great completeness; and, to some extent, he has followed out nearly all the lines of enquiry which arise from the main subject of the paper.

I have had an opportunity of seeing some of the illustrations the author has prepared and these are equally interesting with the rest of the paper. When we consider that such papers as these are of very great interest to people not acquainted with the local conditions, it adds much to their value when illustrations such as the author has prepared, are attached to them.

The author's collection of specimens also I think is extremely interesting, and I have been wondering what he intends to do with it. I think it would be a pity if a collection of that kind were broken up in any way. Its chief interest lies in the fact that it contains practically the whole outfit of the primitive miner and, I think, if kept together and presented to some suitable quarter the collection will serve the best purpose to which it can be put.

I have very great pleasure in seconding the vote of thanks to the author.

The vote of thanks was agreed to *nem. con.*

THE APPLICATION OF THE THEORY OF PROBABILITY IN THE DETERMINATION OF ORE RESERVES

By G. A. Watermeyer (Member of Council.)

(Printed in Journal, January, 1919.)

DISCUSSION.

Mr. Watermeyer gave a short introduction of his paper, and demonstrated briefly an experiment.

The President: This paper, which the author has compiled with great care and study, has only been in your hands a few hours owing to circumstances over which the Secretary had no control. Therefore, it is quite useless to attempt a discussion on it to-night. Those who have glanced through it will obviously understand the trouble and care that the author has taken in preparing it. Whether, on perusal, you will agree with his views remains to be seen, and I hope that many of you who are conversant with this particular abstruse subject will make your voices heard. He mentioned Galton as waxing eloquent on the charm of statistics. If he had only been connected with gold mining he would never have made such a statement in his life.

I hope to say something later on the subject, because it is one of very great importance; and I will just leave the matter there by thanking the author very much for bringing it forward, and I hope that the discussion that follows on it will be worthy of the trouble he has taken in writing the paper.

THE ESTIMATION OF INJURIOUS DUST IN MINE AIR BY THE KOTZÉ KONIMETER.

By John Innes (Associate).

(Printed in Journal, March, 1918.)

REPLY TO DISCUSSION.

Mr. John Innes *(Associate):* I was pleased with the reception accorded to the paper, and wish to thank all who joined in the discussion, which, however, has extended far beyond the subject covered by the title. In this reply an endeavour is made to include this extension.

I regret that more of those who were not convinced of the superiority of the koni-

meter did not have sufficient interest to speak on this matter.

The experience and results of the last eleven months' work which I shall give you, will indirectly answer some of the criticisms brought forward.

It was not my intention to depreciate the good work done in the past by the sugar-tube method, and I can readily believe that konimeter samples taken ten years ago would be uncountable owing to the enormous amount of dust present. At the same time, I recognised that the best method of estimating dust in air was a scientific question to be dealt with in a scientific manner, and therefore I was opposed to the attitude of many who appeared to be prejudiced in favour of the sugar-tube method.

There is no doubt that the use of the konimeter requires greater care and skill on the part of the mine dust sampler than is required by the sugar-tube method, because in the first case, all the work is done on the mine, although this should not be necessary, whereas in the latter method, he has only to supervise the pumping. Some attention is required to keep the konimeter in a good working condition.

Mr. Weinbren noticed that counting affected his eyesight, but the dust sampler on the Ferreira Deep has been using the microscope for counting since December, 1917, without noticing any effect. The microscope used by Mr. Weinbren on the Robinson Deep was not good enough to obtain proper illumination of the dust particles, and this probably accounts for the strain on the eyesight. As suggested by Mr. Adam, counting is dispensed with on some mines, the sample being classified as bad, fair, good, etc., according to its appearance, and this is quite sufficient for most purposes.

Mr. McArthur Johnston mentioned Dr. Hill, of Chicago, as having used an instrument similar to the konimeter, and Capt. Carson of the American Red Cross Expedition to Palestine also spoke of Dr. Hill's work. I have been in communication with Dr. Hill, and he was good enough to send me a pamphlet describing the various attempts that he, and others, had made to determine the amount of dust in air. The final design was on the konimeter principle, and consists of a hand pump which draws air through a cylindrical nozzle ½ in. in diameter. The dust is caught on a sticky surface, but he found that only a certain percentage is caught on the first surface. The volume of each stroke is 1 cub. in., and the minimum number of strokes which would be made in a room where no attempt had been made to free the ventilating air from dust is five. This is equivalent to 328 cc., or almost 66 puffs with the Kotzé konimeter. It would appear therefore that Dr. Hill's instrument is considerably less efficient than the konimeter, due possibly to the low air velocity through the nozzle, which is five times the diameter of that used in the konimeter, and also to the distance of the nozzle from the slide.

Dr. Hill stated that the chief objection he saw to the konimeter was the fact that all dust might not be caught on the slide. It is obvious that with large amounts of dust the vaseline would be covered with a layer of particles which would prevent others from finding any sticky surface for attachment, and in most cases a certain number of particles would strike others and pass over, so that if the konimeter is to be made absolute, the air should be made to pass through more than one nozzle to catch the dust which comes over from the first slide. This leads to the latest developments of the konimeter. No definite results are yet available, and I am indebted to Mr. Harris of the Princess Estates for many of the ideas which I shall now place before you. Mr. Harris designed a konimeter with two nozzles in the hope that it would be possible to obtain a classification of the dust. It was expected that if the air passed through a nozzle 1 mm. in diameter placed, say, 2 mm. from the slide, and then through another 0·5 mm. in diameter, placed 0·5 mm. from the slide, only the large particles would have sufficient momentum to reach the first slide, while the small ones would be caught on the second slide. I had a konimeter made with two nozzles as above, but unless large amounts of dust were present, practically all was caught on the first slide, and where the amount was sufficient to give a spot on the second slide, actually only the finest dust came over. Classification was not obtained, however, on account of the large amount of fine dust which was caught on the first slide. Further experiments in this direction may be indicated. Their aim was, if a count of 200 particles per cc. is the allowable limit, to design a nozzle which will only catch this amount on the first slide: then any spot on the second slide will indicate the degree of danger. The latest

konimeter designed by Mr. Harris will make both spots on one slide, which is a great advantage.

I have here (exhibiting) a double nozzle circular konimeter which he has designed. Its chief features are the flush nozzles, which allow large air spaces to be eliminated, and the metal slides which fit into each other when being transported.

Mr. Harris has also carried out experiments with the sugar-tube method, which have a bearing on the konimeter method, a short account of which he has kindly allowed me to place before you. He fixed up a chamber through which the air passed after having gone through the sugar-tube. A vaselined slide was placed in this chamber on to which the air impinged. In a damp atmosphere he found that on each of the first five strokes of the pump the amount of dust caught on the slide was uncountable, and that only when the sugar became moist did it appear to catch the dust, but by no means even then did it catch all the dust.

In the crusher house on a dry day where the sugar did not become moist, he found large amounts of dust passing over all the time, and believes that the weight found by the sugar-tube under such circumstances is due almost entirely to the large particles caught by the cotton wool. I have repeated these experiments and have here a sample of the dust caught in this manner. The dust is easily seen without the aid of a microscope, and includes a number of small crystals of sugar.

In my tests the tube leading from the sugar was not reduced in diameter, so that possibly a large amount of dust was not caught, and I am thus unable to fully confirm Mr. Harris's experience.

Mr. Harris expresses the opinion, which seems reasonable, that the catching of dust by moist sugar is really done on the konimeter principle, because the rapid passage of air through the small irregular spaces between sugar particles, causes it to impinge on a large number of moist faces, and the dust is caught just as it is in the konimeter. If this explanation is accepted, and if bulk samples are still desired, the future development of a process by which accurate gravimetric results are obtainable are indicated from Mr. Harris's experiments. The konimeter principle can be used on a large scale, as in the sugar-tube method, but dry sugar must be replaced by a more suitable catching medium, and the necessary air velocity can be obtained directly by nozzles. The gravimetric method, however, will always be open to the objection that most of the weight might be due to non-injurious particles.

An objection to the konimeter which was not raised in the discussion but which exists in the minds of many, is that the count might include many particles which do not consist of quartz. When it is considered that the rock blasted, drilled and lashed is practically pure quartzite, this does not seem a serious objection Even if the konimeter only recorded the existence of the minerals in the rock other than quartz, it is reasonable to suppose that the number of quartz particles present in different samples would be comparable to the counts of the other particles, though many times greater. It must be remembered that many of those who make this objection do so in distinction to the sugar-tube method, but what assurance have we that the weight determined by a gravimetric sample is due to quartz alone? The replacement of vaseline by a substance having the same refractive index as quartz might give an idea of the amount of other minerals present.

The classification of mine air as adopted by Mr. McArthur Johnston on the Gold Fields Group seems suitable. The rule of taking a sample close to the head of the worker is a good one, although this has been observed by us, because comparisons were nearly always made with the sugar-tube method.

The fact that a well ventilated place is better than a badly ventilated place is obvious for the reasons given by Mr. Woodburn, and a test lasting for four days was made to obtain some evidence on this point, which is dealt with later in connection with Jack hammers.

What count of dust per cc. in mine air would be considered dangerous is unknown, and reliable information would only be obtainable by experiments with rats combined with konimeter samples as suggested by Dr. Pratt Johnston. Indirectly, the incidence of miners' phthisis in future years might help to fix a standard.

The type of machine drill used in obtaining comparisons was purposely not mentioned, as the paper was not dealing with the relative dust merits of machine drills. As pointed out by Mr. Ingle, a certain type of machine suited my purpose admirably for comparisons owing to the fact that practi-

cally all the dust produced was under 10 microns, so that the gravimetric result was low even when the count was high.

Mr. E. C. J. Meyer is interested in the dust produced by the Leyner. The tests made by us with this type of machine, the results of which will be given later, indicate how much of the dust may be eliminated without troubling much about correct relative pressures and other ideal conditions unobtainable in practice.

Mr. Whitehouse mentioned that different konimeters gave discordant results. This is possible, because standard instruments are not obtainable at present; the nozzle, its distance from the glass, the air velocity, and sometimes the volume of air are different for each model. Three konimeters were tested on the Ferreira Deep, the greatest variation over a large number of spots being 10%, probably due to a combination of the above factors, as all the konimeters differed in one or more details. Greater differences than 10%, while possibly due to the konimeter, are more likely due to the incompetence of the sampler.

Mr. Whitehouse also states that there are cases where the sugar-tube showed considerable weight, but the konimeter gave no spots. I have already shown what a small percentage of spots are not counted including losses from sources in addition to that due to the failure of the konimeter to make a record. Up to the end of February, 1918, this was given as 2·6%. Since that date and up to the 18th December, 1918, 3,522 spots were made, and 3,459 counted, a loss of 63. Of these four slides with 6 spots on each were broken underground. The percentage loss for this latter period is 1·8%.

I do not follow the purpose of the comparison made by Mr. Whitehouse of microphotographs Nos. 26 and 34. The fact that the weights are nearly equal, but that the one contains twenty times more injurious particles than the other makes the comparison useful in showing up the deficiencies of the sugar-tube method. The fact that the sugar-tube does not suggest this enormous difference is because the injurious dust is so fine that its effect on the weight is negligible.

The following figures show the result of the first year's work with the konimeter used in comparison with the sugar-tube.

To the end of August, 1918.

Type of work	Results	No. of Samples	Average count per cc.	Average weight mgr. per cc. metr.	Particles per mgr. units
Reciprocating Machines	Stopes	152	113	2·9	39
	Drives	9	209	5·3	39
	Winzes	13	336	8·2	41
Hammer Type Machines	Stopes	76	209	2·3	92
	Drives	12	286	4·1	70
	Raises	25	326	3·6	90
Hammers	Stopes	58	70	2·5	28
Ore Boxes	Shaft Stations	74	89	3·5	25
Downcast Air		20	34	2·5	14
Upcast Air		254	103	1·0	101

All the counts here, and in subsequent tables and diagrams, are of particles under 5 microns in diameter.

The figures for upcast and downcast air include sampling since August, 1918, and upcast air includes many samples taken when dust due to blasting was present in the air. The average count from this table is 128, and the average weight 2·3 mgm., so that 55 particles equal 1 mgm. Diagram No. 1 (see next page) has been plotted on this basis, and shows the weights which would be obtained in each case for a count of 55 particles per cc. This diagram answers a query made by Mr. Adam relative to the agreement between the konimeter and the gravimetric results.

The circular konimeter introduced by the Dust Inspector for the Chamber of Mines has been used in conjunction with the Kotzé, but it was too erratic until fitted with a conical nozzle in place of the cylindrical one. It was altered also by largely reducing the air space, and by screwing the brass plate down on to the glass slide to prevent air leakages. A large number of glass slides have been broken, and the material by which the glass is glued to its brass frame comes out on to the rubber ring, which makes it difficult to turn the slide. On several occasions the glass has become loose and stuck to the rubber ring, while the brass ring has turned round so that all the spots were taken in the same place. Its use has been discarded for the present on the Ferreira Deep, but an improved konimeter of that type might still be useful. Another objection to the present

type is that during the time taken in counting 30 or 60 spots there might be considerable contamination of the disc by coarse dust. This could be overcome by a dust proof cover.

This type has been recently improved by Mr. Harris in connection with his double nozzle konimeter. The slide is designed to move automatically after each sample has been taken, the air spaces are less, and the spots form a spiral, so that a large number may be taken on a disc. The new model, by slight alteration, can be made to move the disc while the sample is being taken, which should eliminate the necessity of a second nozzle for large quantities of dust, as a fresh surface is always being exposed to the puff of air. The sample would then occupy an elongated area, and the estimation of dust might be facilitated as it would only be necessary to count a section through this area—say one-fifth or one-tenth.

Dust sampling can be placed on a more exact basis by the design of an automatic konimeter driven by clockwork, which would take samples at half-hour intervals. A number of these could be placed at suitable positions underground, and the dust inspector would merely wind up the clock each day and put on a clean slide. When sufficient information was obtained in one place the instrument would be removed to another. Mr. Lindemann, of the Scientific Instrument Works, hopes to have such a model ready shortly, and its use in sufficient numbers should remove an objection to our present system which derives conclusions from samples taken during one small portion of the shift only.

Mr. Weston states that if the injurious dust only varies from 70% to 95% the gravimetric method is not rendered useless. The usual variation, however, is between 95% and 100%, and in very few underground samples will the percentage fall below 95. If you assume the injurious dust to average 1 micron, and the non-injurious to average 10 microns in diameter, even this small range of 95% to 100% renders the gravimetric method useless, because if the total number of particles in several samples is the same, the weight is increased eleven times if the percentage of fine dust changes from 100% to 99%, twenty-one times if it changes from 100% to 98%, thirty-one times from 100% to 97%, one hundred and one times from 100% to 90%, etc.

Mr. Adam states that the smallness of the sample is the chief objection to the konimeter, but the reason underlying my statement that small samples are quite sufficient is that fine dust particles act practically as molecules of a

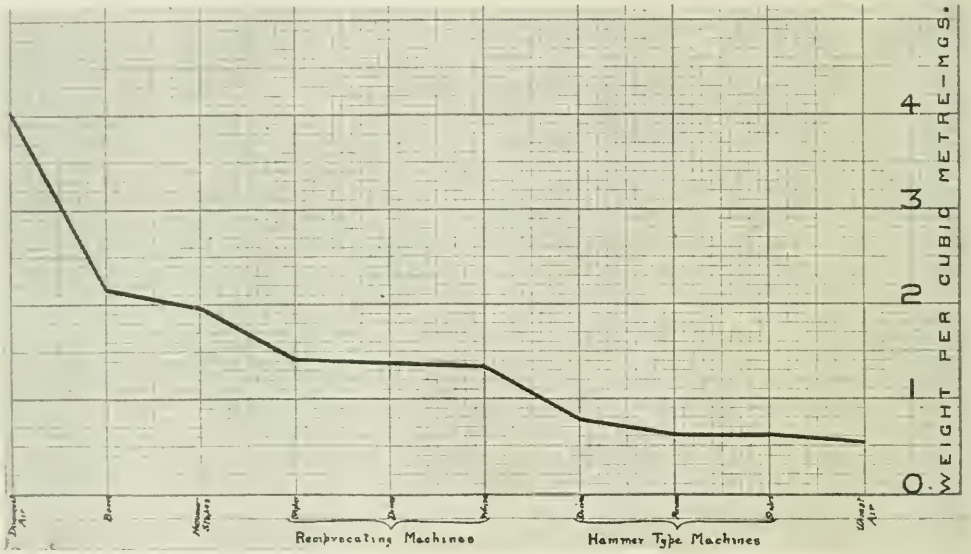


Fig. 1.—Diagram showing comparative weights of a count of 55 particles per cc. for different types of dust.

gas. In sampling a dump for its gold contents a fairly large sample is necessary because a solid is being dealt with; a small sample would give accurate results if the material were a liquid; and if the medium is a gas a still smaller sample should give correct figures. What amount of air is small enough to give reliable results might still be a debatable point, but from our counts of sets of six 5 cc. spots, it would appear that such samples are sufficient, and the results which are given below support this statement.

The differences between the spot photographed and the average count, as pointed out by Mr. Adam, is partly accounted for by the fact that the largest spots were usually chosen as they were the easiest to photograph, and also because the spots photographed were carefully counted afterwards, while no attention was paid to the remaining spots to see if the original average was still correct. In the case of large counts not much care had been taken to get an accurate figure, because if the count was large the sample was labelled "bad," and it did not matter much whether the count was 500 or 700.

Again, the first six months' work was largely experimental, two dust samplers were trained in that period, so that the figures given should not be subjected to a severe ordeal.

The average gravimetric determination of the dust in the downcast air samples on the Ferreira Deep is 2·5 mgm., while the average of those shaft boxes, which are all within 100 ft. of the downcast shaft although in some cases separated from it by ventilation doors, is only 2·6 mgm. Similar figures for the counts are 34 and 60 respectively. Attention has been drawn to these figures to show that the shaft boxes have apparently added only 0·1 mgm. to the downcast air, and considerable expense might have been incurred in the endeavour to reduce the weight of 2·6 mgm., while the great proportion of it may be due to coarse dust in the downcast air. It is possible that the reduced air velocity in the cross-cuts causes the large particles which make up the weight found in the downcast air to settle rapidly, but until additional information is obtained on this point, no reliance should be placed on the figures obtained in any locality unless the dust entering that locality with the ventilating current is eliminated. If the rapid settlement of large particles is accepted to account for the extraordinary results found by the gravimetric method in the above case, it must be acknowledged that the konimeter, with its count of injurious dust which takes much longer to settle, gives a truer idea of what really occurs.

I thank Dr. Moir for his contribution in answer to Mr. Weston's remarks, and would like to point out that the argument for the konimeter does not depend on the size of dust which is actually injurious, because even if particles up to, say, 40 microns in diameter can produce miner's phthisis, the konimeter still provides the better method because it is quicker, cheaper, more reliable, and the appeal it makes is to our sense of sight which is always an advantage.

Owing to the interest taken in the dust produced by machine drills, and thanks to the facilities afforded by Mr. Selby, Manager, Ferreira Deep, tests were made of a few types to find out how the dust was produced by each. The tests were carried out in a winze which was ventilated by 7,000 cub. ft. of air per minute from the upper workings of the Village Deep. This air was sampled at the beginning and conclusion of the test, and was regulated by means of a door. It was thus possible to sweep out all the dust produced by each jumper before drilling started with the next.

When drilling was about to commence, the door was shut. A slight leakage of air through the door tended to produce a movement of the air up the winze, although this movement was not perceptible, so that the samples were taken about 10 ft. above the machine. The air used for cleaning out the winze was fairly uniform in dust content, *i.e.*,

No. of Test.	Type of Machine.	Method of Applying Water.	No. of Spots Counted.	Original dust in air count per cc.
1	Reciprocating	Hose	12	59
2	Reciprocating	Hollow Steel	24	83
3	Leyner & B.C. 22	Hollow Steel	60	89
4	Leyner & B.C. 22	Hollow Steel	24	70
5	Hydromax	Hollow Steel	24	91
6	Jack Hammer	Hose	36	86
7	Jack Hammer	Hollow Steel	12	68

Sugar-tube samples were taken with each jumper used, except in the case of the

Jack hammer, when two jumpers went to one sugar tube sample. In the latter case the gravimetric result for each jumper was obtained by assuming that it would vary as the count. This has the effect of making the gravimetric result conform to the count more than it might have done.

Test No. 1.

Reciprocating machine—$2\frac{3}{4}$ in. Holman
Clean water—High pressure—Hose.
Two down holes.

No. of Jumper.	No. of Konimeter spots counted.	Average count per cc.	No. of Gravimetric samples taken.	Average weight in mgs. per cu. metre.
1	9	88	2	6·0
2	12	74	2	2·4
3	12	89	2	2·1
4	12	75	2	Trace

The konimeter appears to be more consistent here, because if 2·4 mgm. and 2·1 mgm. are reasonable weights for the dust produced by the second and third jumper, there is no reason why the weight should fall to a "trace" for the fourth jumper.

The high weight obtained with the starter may reasonably be accounted for by the presence of coarse particles of dust due to collaring.

Test No. 2.

Reciprocating machine—$2\frac{3}{4}$ in. Holman with Ferreira water attachment.
Clean water—High pressure—Hollow steel.
One down hole, one up hole.

No. of Jumper.	No. of Konimeter spots counted.	Average count per cc.	No. of Gravimetric samples taken.	Average weight in mgs. per cu. metre
1	12	92	2	1·8
2	12	60	1	1·3
3	12	26	2	2·6
4	6	26	2	0·8
5	6	36	2	1·0

To those who think that the gravimetric method is more consistent than the konimeter, the 2·6 mgm. obtained with the third jumper must be difficult to account for.

Test No. 3. Leyner and B.C. 22.
Clean water—High pressure—Hollow steel.
Four down holes, three up holes.

No. of Jumper.	No. of Konimeter spots counted.	Average count per cc.	No. of Gravimetric samples taken.	Average weight in mgs. per cu. metre.
1	57	139	10	2·7
2	33	109	7	2·0
3	34	80	6	0·5
4	26	108	5	1·8
5	6	104	1	2·4

The weight obtained for the dust produced by the third jumper falls to 0·5 mgm., which does not appear to be consistent.

Test No. 4. Leyner and B.C. 22.
Dirty water—High pressure—Hollow steel.
One down hole, two up holes.

No. of Jumper.	No of Konimeter spots counted.	Average count per cc	No of Gravimetric samples taken.	Average weight in mgs per cu. metre
1	18	227	3	3·5
2	18	336	3	1·8
3	18	213	3	2·7
4	18	261	3	2·3

The much higher counts with the use of dirty water show that the large amount of dust obtained in many previous samples, may have been due to the atomisation of dirty water. The third test shows that there cannot be much objection to the Leyner type of machine if used with clean water, but in all machines which send air and water through hollow steel, failures of the water service, unless immediately noticed, cause an enormous amount of dust to be produced, which will always be an objection to this type.

Test No. 5. Hydromax.
Clean and dirty water—High pressure—Hollow steel. Three up holes.

No. of Jumper.	No. of Konimeter spots counted.	Average count per cc	No. of Gravimetric samples taken.	Average weight in mgs. per cu. metre.
1	24	52	4	2·0
2	18	64	3	0·8
3	18	50	3	1·0

This was a new machine, and the use of dirty water had no effect on the count.

Test No. 6. Jack hammer.
Clean water—High and low pressure—Hose.
Five down holes.

No. of Jumper.	No. of Konimeter spots counted.	Average count per cc.	No. of Gravimetric samples taken.	Average weight in mgs. per cu. metre.
1	23	119	7	1·9
2	14	228		3·2
3	15	197	4	6·3
4	7	644		9·4

The use of high or low pressure water made a difference to the count. Dry clouds of dust come out in puffs from the hole with the third and fourth jumpers, indicating that the water did not always reach the bottom. This is a highly dangerous type of machine when used otherwise than as in Test No. 7.

Test No. 7. Jack hammer.
Clean and dirty water—High pressure—Hollow steel.
Three down holes.

No. of Jumper.	No. of Konimeter spots counted.	Average count per cc.	No. of Gravimetric samples taken.	Average weight in mgs. per cu. metre.
1	18	80	3	1·9
2	18	64		1·6
3	18	60	3	1·0
4	18	58		1·0

The use of air and water through hollow steel, lubrication being by means of grease, renders the Jack hammer type comparatively harmless. Dirty water had no effect on the count. When this machine is used for drilling up holes, and the supply of water is insufficient, the slime from the hole runs along the jumper to the chuck where it meets the escaping air. To prevent atomisation of this dirty water a piece of rubber hose should be placed round the jumper so that the slime will run off before it reaches the chuck.

Additional tests of these two types of Jack hammers were made during the present week. A stope was chosen which had not worked away from the original winze at the top, and up which 6,000 cub. ft. of air were passing per minute. A door was put in at the top of the winze to control this current. Each type of machine was tested with full ventilation, and then with the ventilation choked down to 110 cub. ft. of air per minute to allow for the exhaust of the machines, and to produce an upward movement of the air. The samples were taken below the door at an average distance of 50 ft. from the top machine. Three machines were worked under ordinary conditions, samples were taken at half-hour intervals after these had commenced drilling, and each test was continued until the end of the shift.

The results are tabulated below, and illustrate the effects of ventilation on the amount of dust present in the air, and the uselessness of comparisons which do not take into account the ventilating current.

Method of Applying Water.	Ventilating Current. Cub. ft. per min. (approx.)	No. of Spots Counted.	Average count per cc.	No. of Gravimetric samples.	Average weight per cub. metre.
Hollow	6,000	60	101	10	1·32
Steel	110	60	172	10	0·18
Hose	6,000	42	231	8	1·16
	110	48	469	8	13·28

The gravimetric results are peculiar.

Four microphotographs have been prepared to give an idea of the type and amount of dust obtained in each case, and as the tests were not concluded until yesterday afternoon, it must be admitted that the konimeter is capable of giving a visual demonstration of its sampling to a large number of people with considerable rapidity.

In the remarks under some of the above tests, it is pointed out that the gravimetric results do not always appear to be consistent, but to obtain additional information by results which would be interesting, samples at half-hour or hour intervals were taken at the fan on the 10th Level, South Reef, East Drive, Ferreira Deep, on two occasions for periods of 24 hours, and once for a period of seven days. 50,000 cub. ft. of air per minute were passing the fan; 10,000 cub. ft. from the Main Reef Leader, and 40,000 cub. ft. from the South Reef. The labour involved was considerable, and I am indebted to Mr. Pulford, Dust Inspector, Ferreira Deep, and to Messrs. Schaap, Simpkins, Brann and von Maltitz, of the survey and sampling staffs, Ferreira Deep, for the succesful carrying out of the sampling.

The first set was taken on Monday, 16th September, 1918, the second set on Friday, 20th December, 1918, and the third set

from Monday, 13th January, to Sunday, 19th January, 1919, both days inclusive.

Samples with the konimeter were taken at half-hour intervals during the day, and at hour intervals during the night. Sugar-tube samples were taken at hourly intervals except during the time that blasting dust was passing the fan when samples at half-hour intervals were taken, except during the first set.

The results of first set are shown in Diagram No. 2. In plotting 1 mgm. per cubic meter has been made equal to a count of 100 particles per cc., the actual ratio being 1 to 101 for all our samples. The counts are much higher throughout than those obtained in the following sets due to the closeness of some working faces to the fan. Most of the work in the immediate neighbourhood had ceased when the second and third sets were taken. The dust on these latter occasions was extremely fine except when blasting dust was passing the fan, when large variations in the sizes of the particles was noticed depending on the closeness of the blasting.

The results of the second set are shown in Diagram No. 3 (see next page), and those of the third set in Diagram No. 4 (inset facing this page).

The results obtained in the last two sets show that there is practically no dust in the air at night-time, that the dust increases daily during the working hours, although the settlement of dust due to the distance of the fan from working faces does not give a true idea of the amount of dust carried in the air in proximity to these faces, and that the dust due to blasting is the real danger in upcast air.

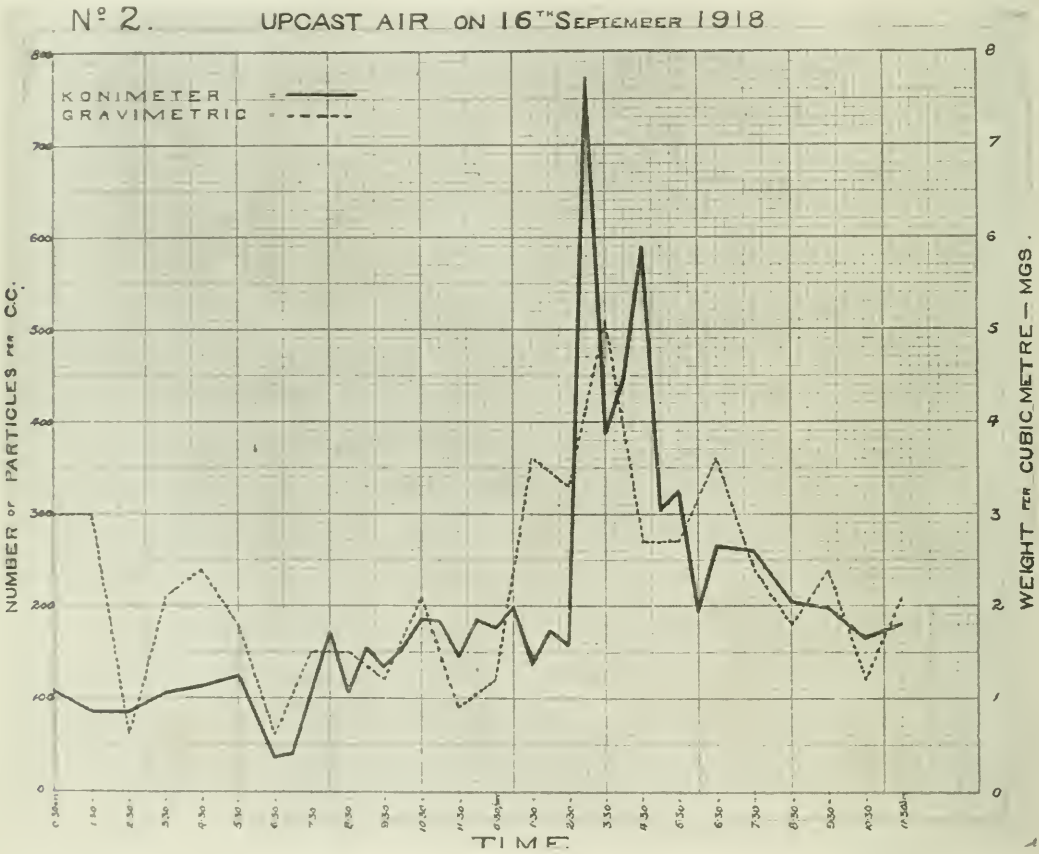


Fig. 2.

The plotting of the week's konimeter curve was completed on Monday afternoon, within eighteen hours of the last sampling of the previous night, so that on seven working days, including one Saturday morning, 1,277 spots were counted, an average of 182 per day. Two-thirds of these were counted

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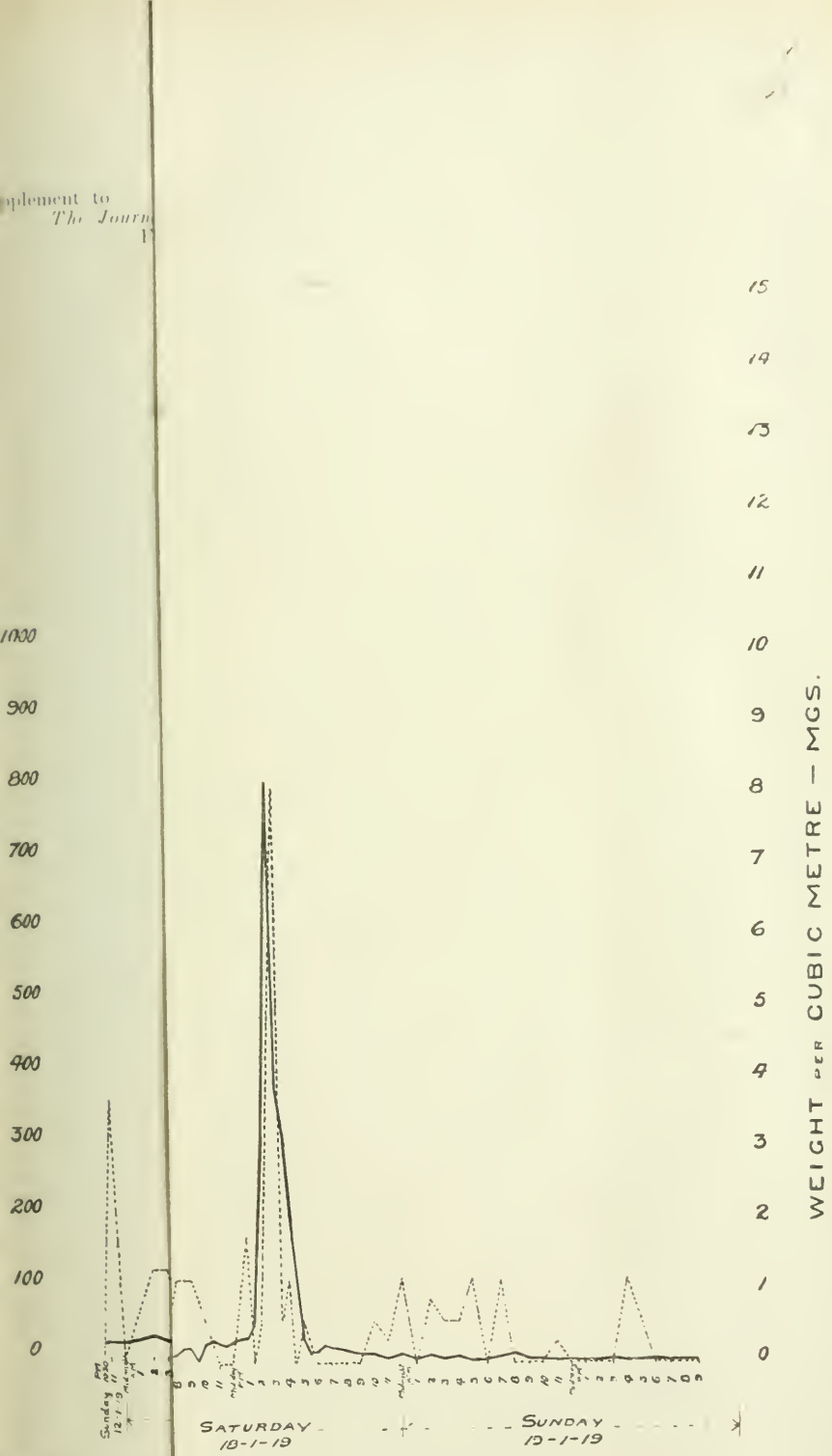
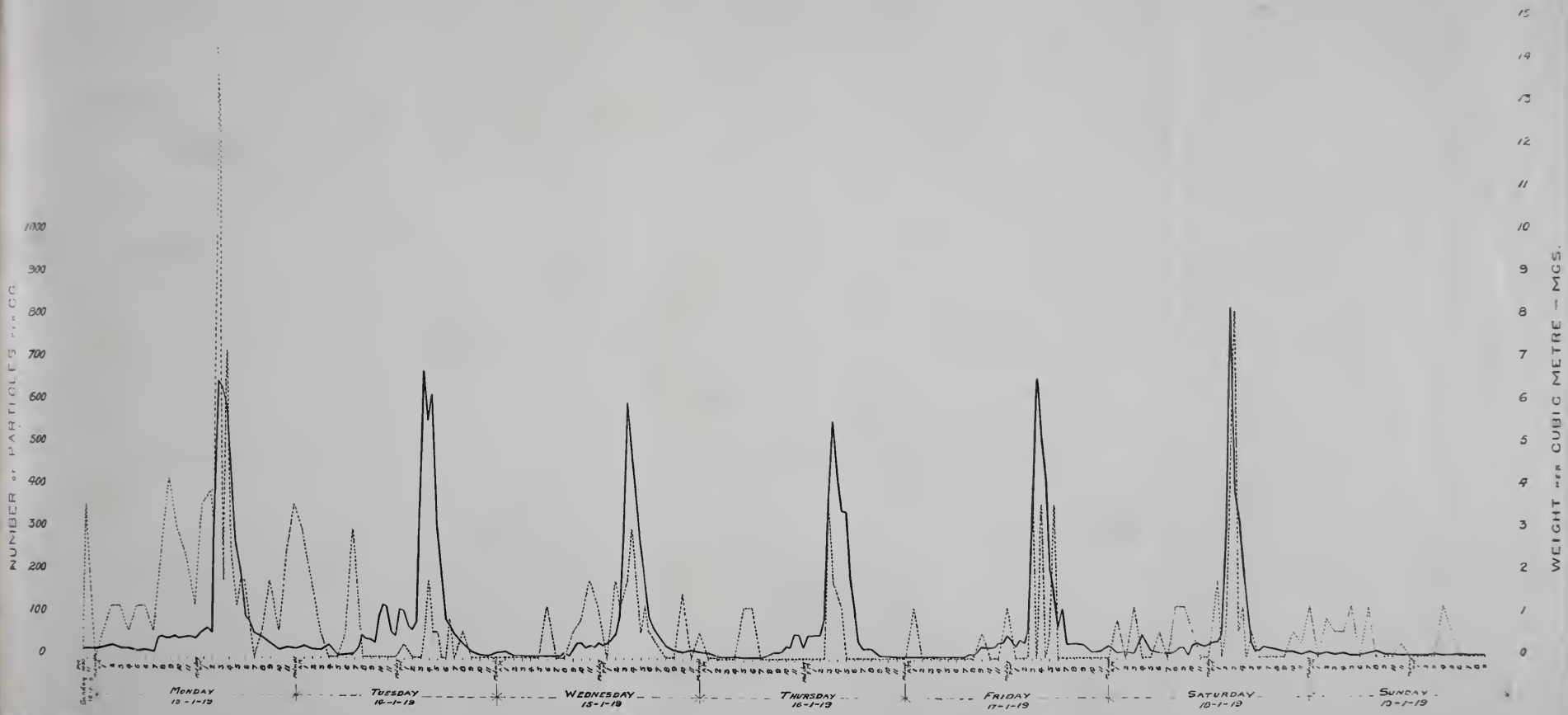


ture page 140.]

WEIGHT PER CUBIC METRE — MGS.

Supplement to
The Journal of The Chemical, Metallurgical and Mining Society of South Africa,
February, 1919. Illustrating Mr. J. Innes' Reply to Discussion.



[See page 140.]

Fig. 4.—Dust Sampling of Upcast Air for Seven Days. Konimeter —; Gravimetric - - - -.

by Mr. Pulford, who, in addition, during the week spent four 8-hour shifts sampling underground, sent off 28 sugar-tubes each day, and prepared every slide for the konimeter. Many of the slides contained very little dust, but the difficulty of finding the spots under such conditions more than balances the time taken in finding and counting spots which contain fair amounts of dust. Marks were usually made on the vaseline by the puffs of air, and although the slide is placed under the microscope in approximately the correct position, it was necessary to make red ink dots on the other side of the glass opposite to these marks to facilitate the search. The gravimetric curve was not completed until the following Friday. While the place chosen for taking the samples is unlikely to give typical results of the dust produced during the working shift, it is eminently suitable for comparisons with the sugar-tube method. The curves show what remarkably consistent results are obtained by the konimeter, and prove the unreliability of the gravimetric method.

From the dust standpoint, there can be no objection to double shifts, if the above results are accepted. The average of the six working days of the third set is shown in Diagram No. 5.

In order to show up the variations of both methods, Diagram No. 6 was prepared at the suggestion of Mr. Selby. It gives the maximum and minimum values obtained during the six working days of the third set, for each time of sampling. The gravimetric method shows large variations, and only at 1 p.m. does it fail to give a trace as a minimum.

The times on Saturday have been altered one hour for plotting this and the next diagram, as blasting occurs an hour earlier on that day.

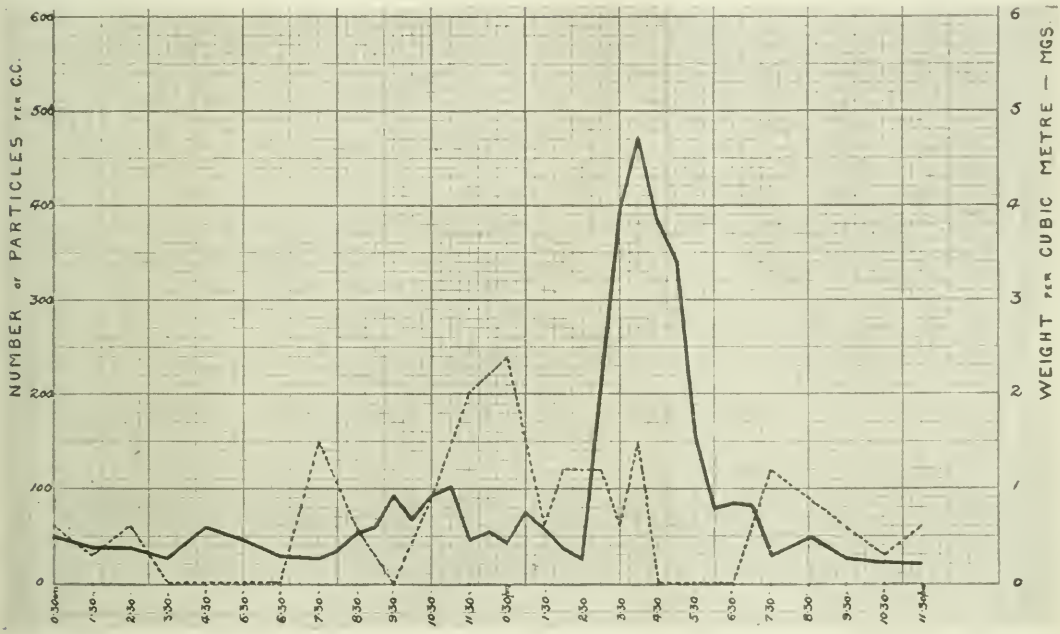


Fig. 3.—Upcast air on 20th December, 1918. Konimeter —; Gravimetric - - - - -

Diagram No. 7 shows the mean errors of one observation in both methods which would be found for each hour of the day. The diagram is derived from the six working diagram is derived from the six working days' sampling of the last set, and shows that the average mean error of the gravimetric method is about four times as great as that of the konimeter method.

The eight working days on which samples of the upcast air were taken have been averaged in the following table, and plotted in Diagram No. 8. The samples taken at the hour have been combined with those taken at the half-hour intervals immediately following, and the results shown as for each hour of the day.

Dust sampling of upcast air on eight working days.

Time.	Number of Spots Counted.	Average Count per cc.	Number of Gravimetric Samples.	Average Weight per cubic metre-mgs.	Number of Particles per mg. Millions.
12 a.m.	66	31	8	0·98	32
1	60	37	8	1·12	33
2	54	26	8	0·52	50
3	53	25	8	0·64	39
4	60	37	8	0·38	97
5	54	28	8	0·52	54
6	48	15	8	0·68	22
7	90	22	8	0·82	27
8	118	42	8	0·71	59
9	108	50	8	0·98	51
10	104	67	8	0·94	71
11	109	66	8	0·89	74
12 p.m.	114	64	8	0·90	71
1	87	75	9	1·10	68
2	113	144	14	1·50	96
3	122	476	14	3·09	154
4	125	434	14	1·90	228
5	105	220	13	0·99	222
6	97	96	9	0·77	125
7	58	69	8	0·61	113
8	53	56	7	0·43	130
9	52	43	8	0·60	72
10	54	33	8	0·54	61
11	54	35	8	0·68	52

This plotting shows the sugar-tube off to the best advantage, but its failure to emphasize the large amount of fine dust at blasting time is noticeable. The high count at 2 p.m. is due to the early blasting on Saturday.

On the average, 10 cc. were used to make each spot in these tests of upcast air, so that the volume of air used for each sample was 60 cc. The sugar-tube sample is approximately 330,000 cc. The proportion is thus as 1 is to 5,500, and as the variation of the gravimetric method is much greater than that of the konimeter, the objection made by Mr. Adam against the smallness of the konimeter sample is not valid.

On two days a konimeter with two nozzles was used during the time that dust due to blasting was passing the fan, but no spots were detected on the second slide, so that the konimeter as originally designed is quite capable of giving reliable results under most conditions that will be encountered underground at the present time.

Diagram No. 9 shows the comparative weights of a count of 50 particles per cc. for each hour of the day for upcast air, and has been derived from the above figures.

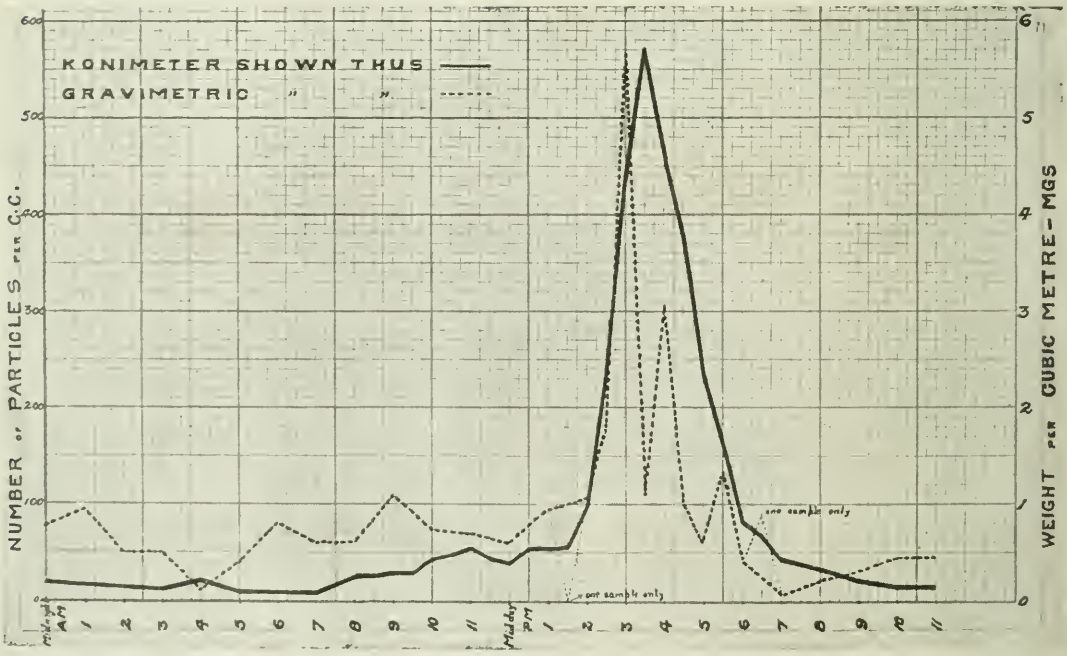
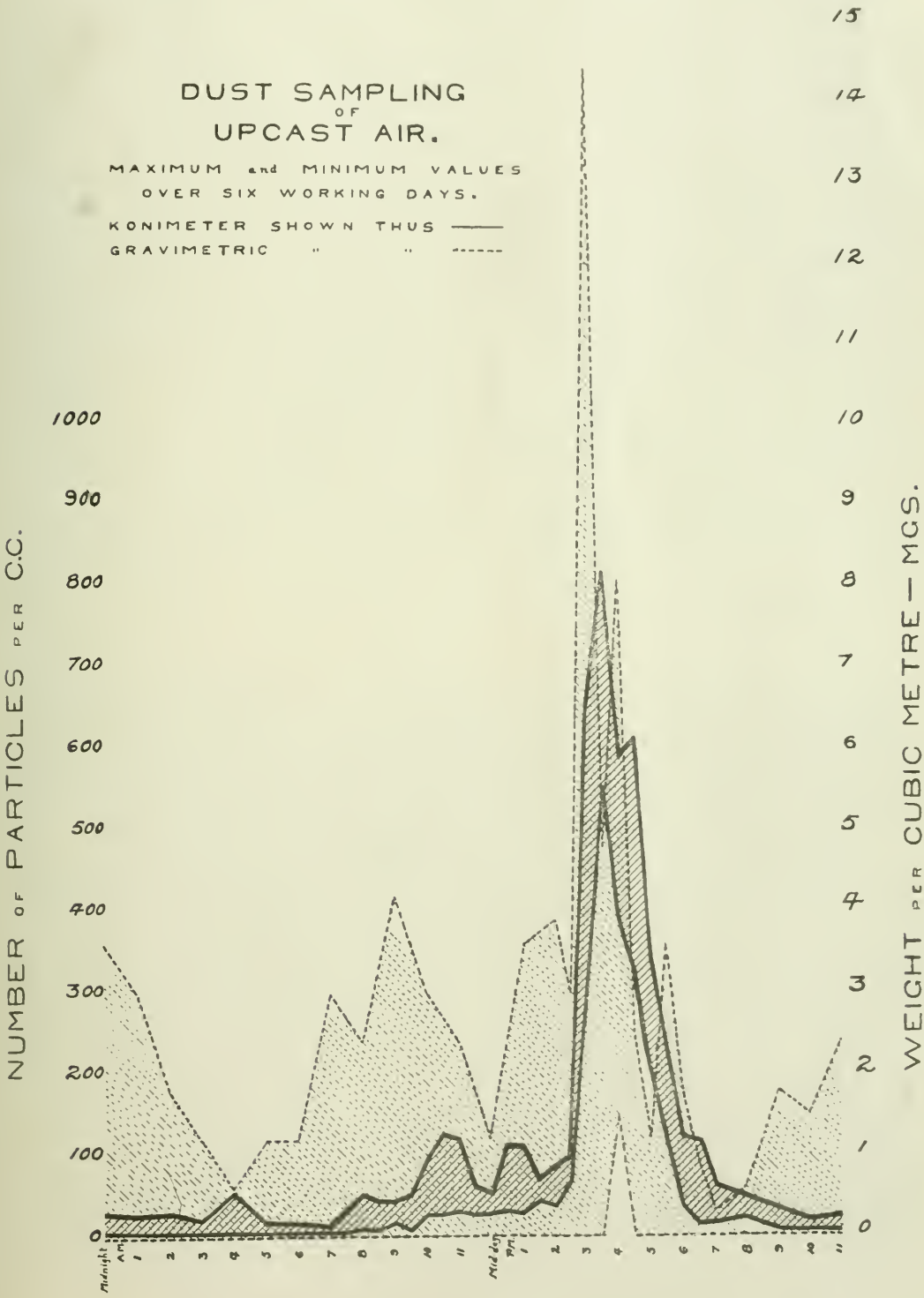


Fig. 5.—Dust Sampling of upcast air. Average of six working days.


DUST SAMPLING
OF
UPCAST AIR.
MAXIMUM and MINIMUM VALUES
OVER SIX WORKING DAYS.
KONIMETER SHOWN THUS ——
GRAVIMETRIC " " ------
NUMBER OF PARTICLES PER C.C.
WEIGHT PER CUBIC METRE — MGS.
1000
900
800
700
600
500
400
300
200
100
0
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Midnight
Am
1
2
3
4
5
6
7
8
9
10
11
Mid day
PM
1
2
3
4
5
6
7
8
9
10
11

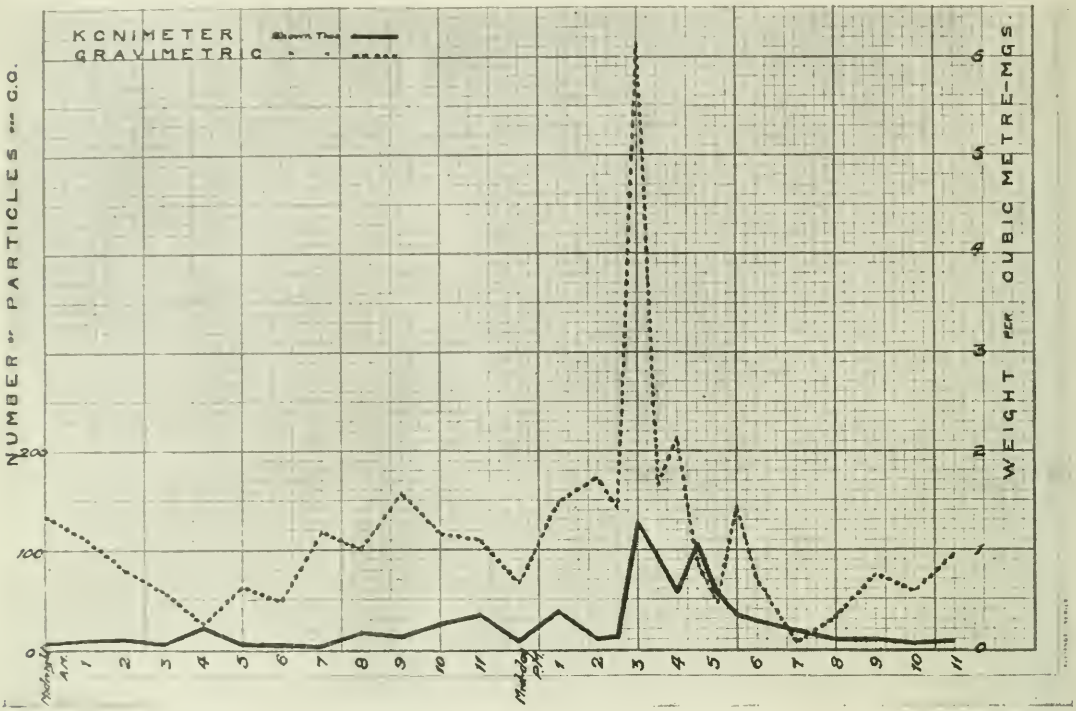


Fig. 7.—Diagram showing mean errors.

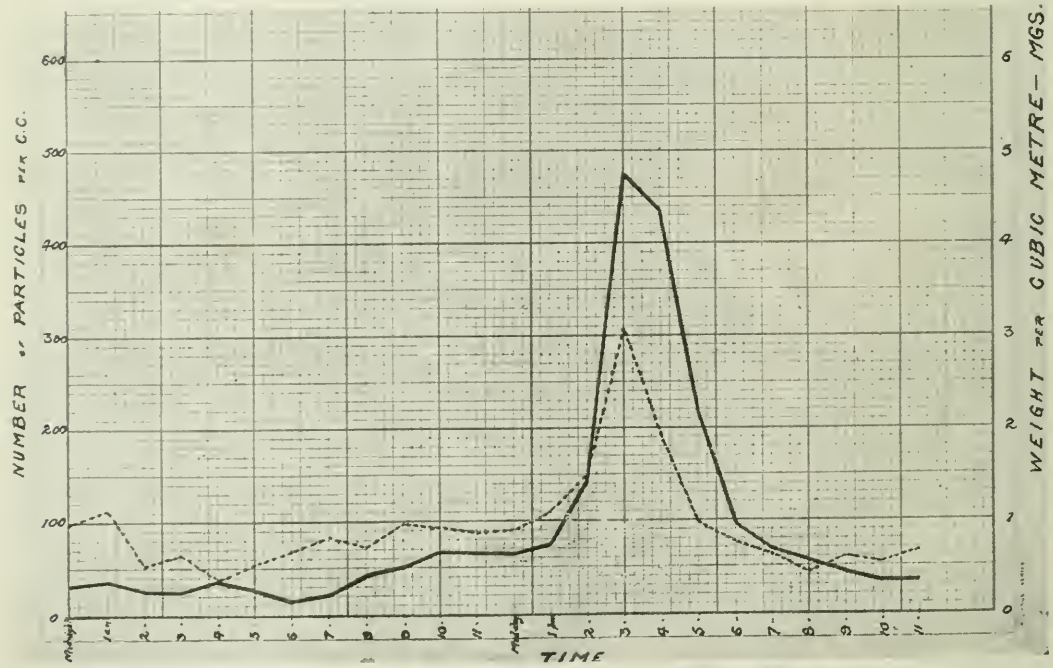


Fig. 8.—Upcast air. Average of eight working days. Konimeter ——; Gravimetric - - - -

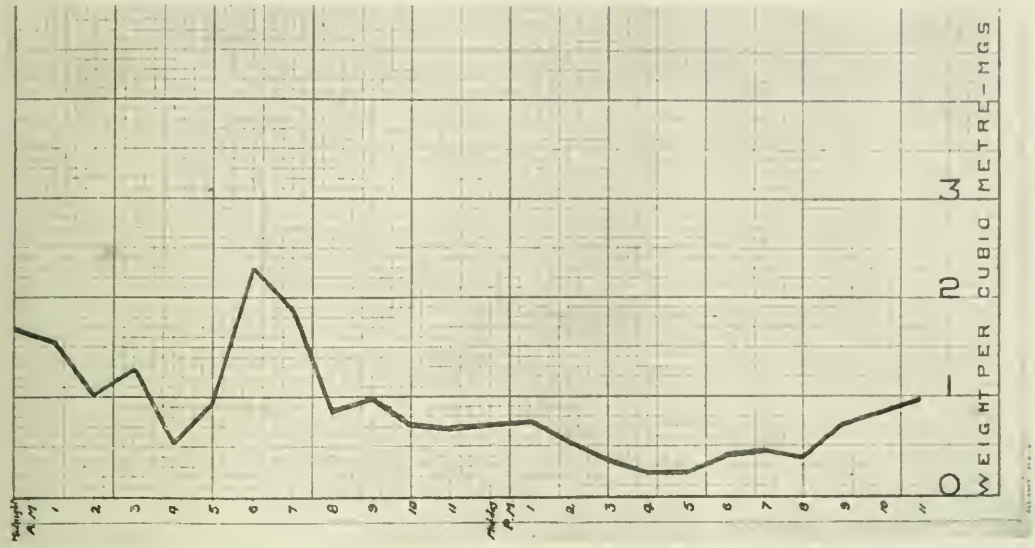


Fig. 9.—Diagram showing comparative weights of a count of 50 particles per cc. for upcast air at hour intervals.

The Dust Sampling Department of the Chamber of Mines was informed when special tests were going to be made, and I am obliged to the Chief Dust Inspector for the supply of the large number of sugar-tubes necessary for the above tests. A special effort was made by his department to return the results of the analyses as quickly as possible.

The President: Although this is a reply made by Mr. Innes to a discussion, it must be perfectly clear to you that it is only the introduction to the subject. His first paper, when he opened the subject, merely touched the whole question. He has now followed this up by an elaborate series of experiments; and I think Mr. Innes will have to reply to the discussion at some future date, because I hope that at our subsequent meetings we shall hear a great deal more criticism and many other views expressed. So I propose, and I hope you will agree with me, that this be not regarded as a reply to discussion but merely the second stage, and that the subject matter shall still remain open.

CEMENTATION PROCESS APPLIED TO MINING (FRANÇOIS SYSTEM).

By A. H. Krynauw (Member).

(Printed in Journal, May, 1918.)

DISCUSSION.

The President: The author was here earlier in the evening and had to leave, but asked me to say he is not so closely connected with cementation as he was at the time he read his paper. As you will recollect, at that time Sir Harry Ross Skinner was present, and he expressed a great deal of regret that the author would not be directly associated any further with this process. But we are happy this evening in having Mr. Blandford here, who has come out from England, and, I think, without flattering him too much, he can be considered as the authority on the subject, and he will be good enough to continue where the author left off.

Mr. Thos. Blandford *(Member):* At the time when the paper was read by Mr. Krynauw the cementation process here was only in its infancy, and he was therefore unable to give a record of definite results obtained. I propose to give you

some particulars and results of some of the more important pieces of work which have been carried out since that date.

Comet Deep, 26th Cross-Cut — First Length of Cementation. — This was mentioned by Mr. Krynauw. The following particulars are of interest:—

Size of the cross-cut, 12 ft. × 8 ft. Approximately 80 gallons of water per minute were encountered at a pressure of 1,200 lb. per sq. in. in the pilot hole. A series of nine holes was drilled in the face and injected.

Total cement used, 8 tons 15 cwt., at a maximum pressure of injection of 3,000 lb. per sq. in.

A test hole was drilled to a depth of 62 ft., encountering no water, and the cross-cut was extended through the cemented area satisfactorily. The cost for completing the cementation work in this length, inclusive of labour, cement, diamond drilling, stores, repairs and compressed air, was £17 19s. 9d. per ft.

26th Cross-cut — Second Length of Cementation.—Water having been encountered in the pilot hole as described in the paper, cross-cut was stopped at a distance of 10 ft. from the first water-bearing fissure In all, three fissures were encountered within a distance of 80 ft., giving 50, 35 and 50 gallons per minute respectively at a pressure of 1,200 lb. per sq. in. A series of 11 holes in this case was drilled and injected.

The total quantity of cement used was 16 tons, 16 cwt.

A test hole was drilled to a depth of 110 ft. and found to be dry. The Cross-cut was then extended through the cemented area, and no water was encountered.

During the excavation a well defined fissure approximately ½ in. wide was exposed at a distance of 50 ft., and found to be sealed up with cement.

The cost of the work of cementation in this second length in the 26th cross-cut, including the same items as before, was £18 10s. 3d. per ft.

Comet Deep, 30th Level West.—A fissure giving 20 gallons of water per minute having been encounted, a 12 ft. brick dam was constructed as mentioned in the paper, suitable pipes being built into the dam for cementation purposes. The dam was then injected and a total quantity of 15½ tons of cement used at a maximum pressure of 1,500 lb. per sq. in. Diamond drill holes were then put in at an average depth of 80 ft., which recorded fissures of 30, 45 and 60 ft., and such fissures were then injected. The total quantity of cement used during this injection was 13½ tons, making a total of 29 tons for the drive.

A test hole was drilled through the centre of the dam to a depth of 100 ft. in solid rock and encountered no water. The dam was then blasted away, and the drive extended through the cemented area, and found to be perfectly dry.

Angelo Deep, 28th West Dam.—It may be of interest to note that a feeder of 3,000 gallons per hour (mentioned in the paper) was successfully closed off after the construction of a dam 5 ft. thick, the quantity of cement used being only 1 ton 11 cwt., at a maximum pressure of injection of 150 lb. per sq. in., the quantity of cement used in the construction of the dam being 3 tons 3 cwt., making a total of 4 tons 14 cwt.

Angelo Deep, 29th West Cross-cut.—Water was encountered in the pilot hole in the face of the cross-cut at depths of 12, 35 and 112 ft., there being 40, 20 and 10 gallons per minute respectively at a pressure of 190 lb. per sq. in.

A series of eight holes was drilled, and each fissure injected separately.

Total quantity of cement used, 6 tons 16 cwt., at an injection pressure of 2,500 lb. per sq. in., a length of 100 ft. being treated.

The cost of cementation in this case, including wages, diamond drilling, stores and compressed air, was £15 0s. 10d. per ft.

Geduld Proprietary Mines, Ltd.—Mr. Krynauw mentions the introduction of the cylindrical concrete dam for the purpose of closing off feeders of water existing in levels, whereby the use of the level is still preserved for transport. Two such cylindrical dams were constructed in two levels, viz., Second Level South and Third Level South.

A few particulars of these two dams may be of interest. In the Second Level South a fissure making approximately 400 gallons of water per minute had been intersected by the drive. A cylinder of re-inforced concrete 30 ft. long was constructed to seal off the area making water and still allow a track to pass through the centre. The material used in construction was 30 tons of cement, 30 tons of sand and 60 tons of stone, and a subsequent injection of 4 tons of cement at a pressure of 4,000 lb. per sq. in. The cost of this cylindrical dam was about £600.

In the Third Level South a fissure giving approximately 500 gallons per minute was

intersected, the size of drive being 6 ft. × 8 ft. A cylindrical dam was also constructed in this level 19 ft. in length, the quantities of materials used being 28 tons of cement, 28 tons of sand and 56 tons of stone, and a further quantity of 12 tons of cement was used for sealing up, this extra quantity being due to a certain amount of dry walling behind the cylinder, the pressure of injection being 500 lb. per sq. in.

The cost of this dam approximated £400.

4th Level, South Drive (Geduld).—A fissure giving approximately 200 gallons per minute was intersected at the face of the drive. A brick dam 15 ft. thick was built 7 ft. from the face, and the intervening space packed with rubble. Suitable pipes were built in for cementation purposes, and the dam injected with a quantity of 21 tons of cement to a maximum pressure of 1,000 lb. per sq. in.

The direction of the drive was subsequently altered and a series of holes was drilled for cementation in which six fissures were encountered, all of which carried water up to quantities of 50 gallons per minute. A quantity of 6 tons of cement was injected to a maximum pressure of 3,000 lb. per sq. in. Subsequently the treated ground was driven through without encountering any water.

Daggafontein Mines, Limited, No. 2 Shaft.—The treatment of the first length of cementation to a depth of 180 ft. has been dealt with by Mr. Krynauw, and it is sufficient to state that subsequent sinking was conducted without any water being encountered.

A plug of safety of 17 ft. of treated ground was left, through which the second length of cementation was carried out and boring conducted by a series of 18 holes down to a depth of 200 ft. The arrangement of the inclination of these holes, however, was altered with the object of cutting or intersecting all vertical fissures. Water was encountered in all the holes at various depths in quantities varying from 4 to 20 gallons per minute. A total of 124 tons was injected to a maximum pressure of 2,500 lb. per sq. in. in this case at approximately a 10% mixture. Sinking has subsequently been carried out through this ground without encountering water.

Brakpan Mines, Limited, No. 3 Circular Shaft.—After fixing the concrete plug in the shaft bottom as mentioned in the paper, 11 holes were drilled from the bottom of the shaft and cementation proceeded with. The total cement used was 494 tons at a maximum injection pressure of 1,500 lb. per sq. in., and in addition to this some 2,200 bags of ashes were also used in the work of filling up the fissures. Sinking was being carried out through this treated ground and no water was encountered, but it is found that a large fissure existed varying from 18 to 24 in. in width and completely sealed up.

No. 4 Circular Shaft (Brakpan Mines).—At a depth of about 700 ft. during sinking a fissure was intersected in the side of the shaft, giving approximately 50 gallons of water per minute. The water in this fissure was dealt with by drilling six holes systematically and injecting a quantity of 1 ton 5 cwt. of cement to a pressure of 400 lb. per sq. in. When this feeder was sealed off a series of 14 holes was drilled into the shaft bottom to further treat this vertical fissure to a depth of approximately 200 ft. Water was found in all these holes in quantities varying from 10 to 80 gallons per minute. A total of 22 tons of cement was injected to a pressure of 2,000 lb. per sq. in. This shaft has since been sunk through the treated ground, and was found to be dry.

Rand Water Board Pumping Station.—At this pumping station cementation was employed upon the main walls and basement floor of the engine house and also upon the engine foundations with the object of solidifying as far as possible the defective ground and concrete foundation work.

Fourteen boreholes were drilled outside the main building to a depth of 24 ft., and cement was injected up to a pressure of 250 lb. per sq. in., this treatment producing a suitable effect upon the walls and wall foundations. The main engine foundations and basement floor were then dealt with by boreholes and further treatment conducted. The concrete generally was found to be somewhat defective and highly porous, and it was found that a considerable amount of cement could be injected at a pressure of 30 lb. per sq. in. into the engine foundations, which should originally have been solid. The total quantity of cement used upon this work was 70 tons.

Considerable disturbance had evidently been created as a result of earth tremors, and previous to the above work being carried out the main engine foundations and engine house walls were subject to heavy vibration and movement, which was distinctly

noticeable, whereas after the cementation treatment a state of rigidity was imparted.

Broken Hill Mine, Northern Rhodesia.—A rectangular shaft, 21 ft. 4 in. × 7 ft. 4in., had been sunk to a depth of 30 ft. through a bed of alluvial ground consisting of clay and boulders which overlies solid dolomite. During the course of sinking very heavy feeders of water were encountered approximating 90,000 gallons per hour. It was decided to attempt to seal off this water and solidify the portion of the shaft already sunk to enable further cementation in depth to be proceeded with and the shaft to be sunk without pumps. A series of 14 boreholes was put down outside the shaft at a distance of 3 ft. from the inside of the timbers, and up to the present time about 60 tons of cement has been injected with the result that the standing feeder of water in the shaft bottom has been closed off, and in addition to this pressures up to 300 lb. per sq. in. are obtainable upon these boreholes, in spite of the fact that they are in such close proximity to the shaft. A certain amount of coke-breeze has also been used in this case for filling purposes.

Mazoe Dam, Southern Rhodesia.—This work, which was mentioned by Mr. Krynauw, consisted of the solidification of a laminated and fissured bed of ironstone rock overlying solid dolomite. In order to construct the dam under ordinary conditions it would have been necessary to excavate a large quantity of this pervious rock down to the water-tight bed-rock, instead of which, by drilling a series of about 80 holes the mass of this ironstone across the site of the dam has been thoroughly treated by cementation, and a quantity of about 290 tons of cement has been used up to pressures of 250 to 1,700 lb. per sq. in. The main portion of the foundation has been completed, and the constructional work connected with the dam itself is being proceeded with. Unfortunately the cementation had to be suspended on account of the influenza epidemic, but a small amount of work only remains to be done to complete the two spillways.

In addition to the above-mentioned applications of cementation which I have picked out, I may say that a large amount of work has been successfully carried out upon water-bearing fissures in levels, shafts, etc., this being a class of work which can very often be carried out very simply and with small expense. I should like to mention here also, in connection with the remarks made by Mr. H. A. White relative to the admixture of other materials with cement to save expense, that in England this principle has been largely adopted for some time in cementation work, and large quantities of finely ground clinker ashes have been employed with every satisfaction.

With the same object in view I have since my arrival conducted, with the assistance of Mr. Toombs, an extensive series of experiments with ordinary dump slime, both in the shape of laboratory tests and also bulk tests, and the conclusions so far arrived at are such that it is now possible to employ a mixture of approximately 50% of cement and 50% of slime for the purpose of filling large cavities which are likely to be encountered in dolomite country. By introducing such material considerable expense may be saved compared with using pure cement, especially when taking into consideration the present market price of cement.

I would like also to call attention to the remarks made by the President upon the subject of the chemical process, which, he observed, had been mentioned in the Proceedings of the Australian Institute of Mining Engineers in 1917. I think that there is no doubt whatever that the first place at which this process was used was at the Hatfield Main Sinking, as a result of considerable research in connection with the treatment of the porous new red sandstone. This process in combination with cementation has also proved to be an unqualified economic success for such measures, and I have heard recently that it is likely to be further adopted almost immediately in the case of six or eight pairs of shafts, which may be commenced now that the war is over.

Finally, I would like to make a few remarks concerning the cost of cementation, and would say that in this country the item of cost requiring most attention seems to be that of the diamond boring, and in one way a large amount of cost can be reduced by using several boring machines at the same time in order to do all the dead boring between fissures as quickly as possible, and so reduce standing charges. Careful control is necessary, and after keeping close record of costs I find that in a recent case the total cost of boring, including labour and diamonds, was found to be only about 10s. 6d. per foot per hole, which is a considerable reduction as compared with the usual recognised price of £1

per foot for small holes, which I have been informed is generally the case. I may say that in England in stratified measures practically all boring for cementation is also carried out with the aid of diamond drills, but the wastage of diamonds is practically nil, and I have known some stones as having been in use for five or six years, and still doing good work.

The President: There is no doubt that this is another paper that cannot be regarded as a final discussion. So I propose that this be left open again in the hope of further discussion.

THE EFFECTS OF DUST INHALATION

By J. S. Haldane, M.D., F.R.S. (Hon. Member).

(Printed in Journal, July, 1918.)

DISCUSSION.

Mr. A. McArthur Johnston *(Past-President):* I would like to read a small contribution from Dr. Watt on Dr. Haldane's paper, and the discussion thereon both here and in England.

Dr. Andrew H. Watt *(Visitor):* I have read with great interest Dr. Haldane's paper and the discussions thereon in this country and in England.

Considerable light, I think, could be thrown upon the subject by our experiences out here. Do coal miners who come to work on the Rand take longer to develop silicosis than men who have not worked in the coal mines? Figures to be comparable should be taken from the same class, *e.g.*, home-born men and colonial-born men, for it is, I think, established that the colonial-born miner is more prone to develop miners' phthisis and tuberculosis than the home-born miner. All this, and similar information, might be obtained from the Miner's Phthisis Bureau or Board. Experiments on animals might be carried out similar to the Simmer Deep experiments Experiments carried out *in situ* are, I think, preferable to purely laboratory experiments. I do not think that a miner affected by silicosis, *i.e.*, fibrosis of the lungs, will benefit much by working in a coal mine. The damage, *i.e.*, the fibrosis has already taken place, and the removal of any siliceous particles from the lungs will not make the fibrosis less. It might prevent any further absorption of silica. We would expect, that if Dr. Haldane's conclusions are correct, the amount of coal dust in a coal miner's lungs would prevent for a time at least, the absorption of siliceous dust.

On the Rand, I do not consider that enough research work has been done on this most important subject. It has been left in the past to medical men and other investigators to do what they could whilst carrying on their usual occupations, which naturally absorb the most of their energies. I think the Government or the industry should secure and pay skilled investigators to go into the whole subject, in the light of present day knowledge, or the Miners' Phthisis Medical Bureau might have a department for research. The present examiners have not the time or opportunity for original work, as all their energies are devoted to the routine work of the Bureau, and examining periodically applicants for compensation and miners. Further use might be made to the mass of figures which must now be available.

The President: It seems to me that the results obtained by Mr. Innes are more important than the method of obtaining them. In combination with the work done and suggestions made by Dr. Haldane we must, if we are alive to our duties, evolve something of value to the industry. I therefore ask you not to leave the subject at the preliminary stage, which is all that it has so far reached, but to follow it up and to let us, as a Society, try to do our best to improve matters and show that we are thoroughly alive to the value of better conditions on these Fields. I may add that a committee of the Chamber of Mines, is engaged in dealing with this subject in an extremely careful and elaborate manner.

FURTHER NOTES ON SANDFILLING OF MINES.

By C. H. Greathead (Member of Council.)

(Printed in Journal, April, 1918.)

REPLY TO DISCUSSION.

Mr. C. H. Greathead *(Member of Council):* I do not think there has been any further contribution by any of the other members on this subject; but since reading my paper, one rather interesting little problem has cropped up in these large sand-filled areas. As you may remember, I

stated at the time that a considerable movement in the ground had been stopped in the large areas that had been sand-filled; but quite recently there has apparently been a further settlement inside those areas which contain a large number of pillars, which have been surrounded by sand. We have had some very heavy earth tremors that we could not trace, and we had an idea that they were due to the bursting of the pillars that had been left. The day before yesterday there was a very heavy shock in the night and in the morning, when the shift went down, we found the drive, near the end of our 29th level cross-cut, entirely closed up, due to the bursting of three large pillars, left near the end of the cross-cut along the drive, which are entirely surrounded by sand for about 500 ft. in every direction. So I think it simply points to the fact that, although the sand is supporting the ground over a very large area, nevertheless there is a gradual settling down of the strata above these pillars, and that, when the pillars reach their bursting point they give, and I consider that in any sand-filling operations one has in view, all pillars, if possible, should be removed prior to filling with sand, to avoid these bursts.

I do not think I have anything further to mention now.

The President: It is very late now, and, I think, if anyone has any further contributions to make on the subjects we have discussed this evening, if they will be kind enough to send them direct to the Secretary, they will be inserted in the *Journal*.

THE ESTIMATION OF OXYGEN IN WORKING CYANIDE SOLUTIONS.

By H. A. White (Vice-President.)

(Printed in Journal, June, 1918.)

DISCUSSION.

Mr. Andrew King *(Member):* The author has brought to our notice a subject which in recent years has received little attention from cyanide operators, and the working method which he has given us as the result of his research is one which will be found of considerable use.

The percentage extraction results in the top compartments of the extractor boxes as given by Mr. White seemed low compared with the writer's experience, but when the corresponding oxygen determinations were made it was seen that the dissolved oxygen in the slime plant solutions in particular was much lower than those given by Mr. White and Mr. Wartenweiler; and this probably accounts for the higher percentage extractions obtained in the top compartments of the extractor boxes as shown by the following results (see table, p. 151).

A complete series of sand leaching was also tested for dissolved oxygen, and the results obtained were much the same as those given by the author, showing a gradual increase in amount of oxygen as treatment progressed.

What would appear to be a serious lack of oxygen in slime plant solutions will be noticed, also that the oxygen dissolved by the solution between the time it leaves the extractor boxes and is brought to rest in first settlement vat is used up before precipitation. Satisfactory extraction of gold from slime is, however, obtained. It must also be mentioned that practically all slime plant solutions tested gave a muddy purplish colour, not strictly comparable with the colour standards, and several of the former quickly became lighter in colour, showing that some oxygen absorbing compound was present in solution. To what this is due has not yet been satisfactorily determined, but it seems probable that the "make-up" water which comes direct from underground and contains a large quantity of iron and alumina in solution, may be the cause in the first instance. The colorimetric oxygen test cannot be applied to this water until made strongly alkaline and filtered, the addition of pyrogallol and caustic soda giving an almost black purplish colour. The comparatively high percentages of ferrocyanide found in the solutions, white precipitate and zinc-gold slime at this plant can be traced to this make-up water.

The author has referred to T. B. Crowe's paper,* from which it would appear that the practical difficulties of extracting dissolved oxygen from cyanide solutions prior to precipitation have been overcome in America. It would be interesting and instructive to know how this is accomplished. The author thinks that agitation or spraying is necessary, presumably because the application of vacuum to a vessel containing a depth of solution does not reduce the amount of dissolved oxygen sufficiently. Would it not be possible to overcome this difficulty by causing the solution to flow through a vacuum chamber with a number

* Abstracted in our *Journal*, Nov. 1918, p. 83.

Table of Results Obtained.—Extractor Boxes.

Extractor Box.	No. of days after dressing.	Leaving Compt.	Temp. F.	KCN per cent.	Oxygen M'gms. per litre.	Gold, dwt.	Extraction per cent.
Strong	15	0	74	0·0320	1·0	2·62	
		1			0·0	0·66	74·81
		2			0·0	0·46	80·39
		3			0·0	0·17	63·04
		4			0·0	0·015	91·18
		5			0·0	0·01	33·33
		6			0·0	0·01	nil
		7 (empty)			trace		
Weak	11	0	75	0·008	5·0	0·17	
		1			0·0	0·05	70·6
		2			0·0	0·03	40·0
		3			0·0	0·01	66·7
		4			0·0	0·01	nil
		5 (empty)			trace		
Slime	14	0	78	0·063	0·5	0·12	
		1			0·0	0·05	88·1
		2			0·0	0·02	60·0
		3			0·0	0·01	50·0
		4			0·0	0·01	nil
		5 (empty)			trace		

Miscellaneous Solutions.	M'gms. O_2 per lit.
Strong solution where it strikes solution surface in sump	4·0
Strong solution sump full before making up to strength	5·0
Strong solution sump made up and circulated	6·0
Strong solution as pumped on to sand vats	7·0
Weak solution where it strikes solution surface in sump	1·5
Weak solution, sump full	3·0
Weak solution as pumped on to sand vats	3·0
Precipitated slime solution where it strikes surface in sump	0·5
Heated solution delivery into intermediate transfer vat	3·0
Unprecipitated solution delivery into intermediate transfer vat ...	4·0
Slime pulp delivery into first settlement vat after circulating	3·0
Solution from same vat after 20 hours settling	0·5
Precipitated solution delivery into second settlement vat	3·0
Solution from same vat after 20 hours settling	0·5

of vertical and horizontal divisions? The solution could then be discharged from the sealed vessel with the aid of a vacuum trap without breaking the vacuum.

I agree with the author that the matter is sufficiently important to be thoroughly investigated by large scale experiments, particularly in view of the considerable saving of cyanide and zinc claimed by Mr. Crowe.

The meeting terminated at 10.45 p.m.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Analysis of Aluminium Alloys.—"In a contribution to the discussion on the above paper, by B. Collitt and W. Regan, Mr. A. W. Willis writes that the estimation of manganese in aluminium alloys may be performed even more simply and expeditiously than described by the authors, as 1 gm. of practically any of the alloys will dissolve readily in 25—30 cc. of nitric acid of sp. gr. 1·20, if a single drop of hydrofluoric acid be added. This immediately causes much effervescence and

rapid solution of the alloy. The solution is then oxidised with bismuthate, cleared and cooled, oxidised cold and filtered through asbestos as usual. The hydrofluoric acid has no detrimental effect on the results, and enables one to work with a much smaller bulk of solution which is better for the oxidation by bismuthate. For nickel estimation, the glyoxime method gives the most satisfactory results, the process being somewhat simpler than that given in the paper, viz., the alloy is dissolved in dilute hydrochloric acid with the addition of a drop or two of nitric acid to get the copper residue into solution, avoiding excess. Then the solution is diluted and about 10 gm. of tartaric acid added, and when dissolved a suitable quantity of dimethylglyoxime solution, and the liquid made ammoniacal and allowed to stand. It is then filtered through counterpoised papers and the precipitate dried and weighed as usual. The aluminium, copper, etc., are kept in solution by the tartaric acid and ammonia, and the nickel precipitate is quite clean. The manganese and nickel processes as above have been in continuous use in a large works laboratory for some years, and are quite satisfactory for ordinary works purposes. Mr. Grisley's suggested method of titrating the copper with potassium cyanide was tried some three or four years ago and the method found to be quite satisfactory with care, but for rapid works check purposes (mostly performed by junior workers) it was found that the iodide method gave a much better end-point, as the cyanide discharges the copper blue colour somewhat slowly and hence requires slower and more careful titration."—A. W. Willis.—*Journal of the Society of Chemical Industry*, May 15, 1918, p. 142T. (A. W.)

Characteristics of Good Nitrogenous Fertilisers.—"Careful measurements have shown that the application to an acre of land of 1 cwt. of nitrate of soda or sulphate of ammonia, or 1½ cwt. of nitrolim, under proper conditions and within certain limits, may reasonably be expected to give the following crop increases :—

	Crop increase.		Present market value of increase.	This increase produces: Calories in millions available for human use.	No. of days for which these heat units will last one man.
Potatoes ...	1 ton.		£6 0	0·96	280
	grain.	straw.			
Wheat ..	4½ bushels	5 cwt.	£2 5	0·36	100
Barley ...	6½ ,,	6¾ ,,	£2 10	0·36	100
Oats ..	7 ,,	6 ,,	£2 10	0·32	94

One cwt. of these concentrated fertilisers is therefore capable of producing enough food to satify a man's bodily requirements for 100 or more days, or, in other words, one pound of combined nitrogen properly used in the soil will yield enough food to keep a man going for about five days. No apology is needed, therefore, for emphasising the desirability of increasing supplies of combined nitrogen.

The normal course of events is for the plant to take up practically the whole of its nitrogen in the form of nitrate : in consequence, the most effective fertilisers are the nitrates of sodium, potassium, ammonium, and calcium. For some of these there has long been a considerable demand, which is likely to be increased if post-war conditions are such that farmers are liable to increase their areas of ploughed land and grow more corn.

Other nitrogen compounds are effective in so far as they can be converted into nitrates in the soil. Ammonium salts come a very close second to the nitrates, since ammonia is rapidly converted into nitrate in the soil by bacterial action, and the process is complete before the plant really needs all the nitrogen that has been applied.

Soil also contains numerous bacteria, capable of rapidly converting protein, amino-acids, and many amides into ammonia, which is then oxidised to nitrate : in consequence protein nitrogen, amino-acid nitrogen, and amide nitrogen are all of great manural value.

Calcium cyanamide (nitrolim) is almost quantitatively converted into ammonia in the soil and thence into nitrate : thus it is also of high manurial value. If the effectiveness of nitric nitrogen is put at 100, ammoniacal nitrogen would be about 95, cyanamide nitrogen about 85 to 90 or more, and protein nitrogen about 70 to 80.

No other combination of nitrogen so far tested is known to have as high manurial value as these substances : plants cannot absorb them as such, and the soil bacteria cannot convert them into ammonia. Thus neither the nitro bodies nor the diazo-compounds, nor the ring compounds resistant to bacterial action in the soil are, so far as is known, of any fertilising value. If it were proposed to utilise any of them as fertilisers it would be necessary first to decompose them and bring them into a form in which they would be convertible into nitrates in the soil.

Besides this requirement that the nitrogen should be convertible into ammonia or nitrate in the soil, there is a second requirement that is equally indispensable. The other constituents should be innocuous to plant and bacterial life : if they are beneficial, so much the better. Plants growing in natural soil are not over sensitive, and the soil organisms, if given time, will oxidise many toxic substances : for example, phenol and cresol disappear tolerably rapidly from soil, being oxidised by some of the organisms occurring therein. But there are some groupings that living plants will not tolerate, and if these are present the material cannot safely be used as manure. The simplest test for these harmful substances is the plant itself. At Rothamsted the test is carried out as follows :—Twelve pots are filled with garden or field soil, and then divided into three sets of four each. In one set the substance to be tested is incorporated in the soil at the rate of 100 mgm. of nitrogen per kilo. of soil : the second set is similarly treated with sodium nitrate also at the rate of 100 mgm. per kilo. of soil : the third set is left untreated. Seeds of wheat, barley, or

mustard are sown according to the season (wheat in winter, barley in spring, and mustard in summer or autumn), and the pots kept equally moistened. The plant rapidly and definitely indicates the fertilising value of the material used, and the presence or absence of toxins. In the latter case, not only is growth depressed below that of the untreated plants, but the young leaves show some abnormal features: the edges or tips may be bleached or withered, or the leaves may be very dark green in colour and curl under, or be otherwise affected. If a toxin is indicated the chemist must find some way of decomposing it.

In studying fertilisers at Rothamsted this test is never omitted. A substance was recently investigated which, from its analysis, seemed most promising as a fertiliser: it was rich in nitrogen, mainly in nitrate form, as the result of previous special treatment. But as soon as it was tried in the pot experiment the young plants were poisoned: the seed leaves became blanched at the edges, and though the seedlings struggled into plants which finally attained maturity, growth was considerably behind that of the untreated soil, and the proposed fertiliser had done more harm than good.

Turning now to the nitrates and ammonium salts, which are known to possess high fertilising value, there are two standard fertilisers with which the farmer is familiar, and which in peace time he can obtain in considerable quantities—nitrate of soda and sulphate of ammonia. Any proposed new fertiliser would have to meet the competition of these, and would therefore need to possess some advantage of cheapness, greater effectiveness or convenience, if it hoped to come into use.

Potassium nitrate has the advantage that it contains potassium which itself is of considerable fertilising value: the farmer, therefore, has two manures in one substance. It so happens that potassium is not very widely needed in England for farm crops, the need being usually restricted to potatoes, mangolds, and clover. Of these, clover does not want added nitrogen, and the potato is rarely supplied with nitrate by the best growers, who consider that it thereby loses in quality: it is instead given ammoniacal nitrogen. The mangold is the only crop requiring both potassium and nitric nitrogen, but it so happens that it needs sodium and chlorine as well, so that nitrate of soda and kainit forms a good combination for the purpose. The farmer is, therefore, not specially drawn to potassium nitrate, and is never prepared to pay a high price for it, certainly not the price that was asked before the war. There is some demand by horticulturists but not much; there may also be the possibility of working up an export trade.

Calcium nitrate has far greater possibilities as a fertiliser, because it is said to be producible at a price enabling it to compete with nitrate of soda. The calcium is somewhat more useful in the soil than the sodium, but, on the other hand, this advantage is offset by the fact that calcium nitrate readily deliquesces, and therefore is not easily stored or handled by the farmer. This can to some extent be overcome by making a basic nitrate, but the percentage of nitrogen then becomes lowered, and the farmer has to pay more per unit of nitrogen for freight, cartage, drilling, and handling than in the case of nitrate of soda with its higher nitrogen content. Probably these disadvantages rather more than counterbalance the advantage of the calcium so that the price of the nitrogen should be somewhat less.

Ammonium nitrate has the advantage that it is very rich in nitrogen, and therefore bagging, freight and transport charges per unit are reduced to a minimum. This is of obvious importance in the home trade, and to a still greater extent in certain branches of the export trade. Unfortunately the advantage is somewhat discounted by the circumstance that ammonium nitrate is deliquescent, and therefore not easily applied to the land by means of the ordinary manure drill. Further, it is so extremely soluble that it plasmolyses the leaves of the young crop to which it is applied. In some of the experiments hitherto made it has not proved equal to nitrate of soda or nitrate of lime; however, it is not to be supposed that the last word has been said on the subject.

Three ammonium salts have been used as fertilisers in addition to the ordinary sulphate. The muriate has been extensively tested and found to be indistinguishable from the sulphate in fertilising action (the basis being equal amounts of nitrogen). If it had any advantage over the sulphate to the works chemist it could be used extensively as a fertiliser.

The old sesqui-carbonate of ammonia was tested some 50 or 60 years ago at Rothamsted, but the results were not very satisfactory.

Ammonium phosphate, like potassium nitrate, has the advantage of supplying two fertilisers in one article, and thus of saving freight, cartage, bags, etc., always a great consideration in the export trade, and not without significance at home. There is, however, nothing to show that it is more effective as a fertiliser than a mixture of sulphate of ammonia and superphosphate, and the farmer would not be willing to pay a higher price. Last autumn sulphate of ammonia was being sold for £15 15s. per ton, and 30% super (*i.e.*, superphosphate, containing water soluble phosphate equivalent to 30% $Ca_3P_2O_8$), at £6 10s. per ton: at present the prices are higher. It is easy, therefore, to calculate what any given sample of ammonium phosphate would be worth in the home market. For the export trade a higher price relatively to the mixture of sulphate and super could be obtained corresponding with the saving in freight.

Ammonium phosphate seems only to have been tested in one experiment in this country, and it did not come out as well as nitrate of soda. This experiment was made at Newton Rigg in 1911.

In the case of other nitrogen compounds it is necessary to ascertain by the direct trial already indicated their decomposibility in the soil and their freedom from harmful constituents. For purposes of preliminary sorting out a simpler test of decomposibility may be adopted. The substance is mixed with soil in the proportion of 100 mgm. nitrogen to 1 kilo. soil, keeping the soil moist, and determining the rate at which nitrates are produced, the first determination being made after 5 days, the second after 10, and the third after 20 days, or a longer period if necessary. A control experiment must also be made with soil alone. Ammonium salts rapidly and completely nitrify in these conditions, so also do some of the protein substances, dried blood, etc. A third lot of soil is therefore put up to which sulphate of ammonia

is applied at the same rate; if this nitrifies quickly one can be sure that all the conditions were satisfactory. Substances that nitrify rapidly can then be tested by the more elaborate plant test."—E. J. Russell. *Journal of the Society of Chemical Industry*, Feb. 15, 1918, p. 45R. (J. A. W.)

METALLURGY.

Amalgamation and Roasting Practice in Gold Coast Colony.—"I shall limit myself in this article to a consideration of the amalgamation and roaster practice in the Prestea Block A mill, the most important plant in the Tarkwa and Prestea gold fields, in the Gold Coast Colony, Africa. A screen analysis of the amalgamation feed was as follows: +30 mesh, 2·65%; +60 mesh, 34·37%; +90 mesh, 16·51%; +120 mesh, 6·19%; and −120 mesh, 40·28%.

The equipment consisted of 22 side-shaking plates making 180 shakes per minute and actuated by a 10-h.p. motor; a clean-up barrel 5 ft. long and 3 ft. in diameter, and two Berdan pans. On day shift the plates were scraped at the head end with steel scrapers and then rubbered up. As the lower end was nearly always stained and scoured, it was cleaned with a little fine sand and ammonium chloride and re-amalgamated. Mercury was sprinkled on, and rubbed in well with a scrubbing brush. The plate was next rubbered up, the surface smoothed with a soft brush, and the final touches given under a stream of water to prevent oxidation of the freshly cleaned plate.

Notes on Care of Plates.—The practice of furrowing the amalgam at the head of the plate with the fingers is not to be commended when the feed contains an appreciable quantity of sulphide particles. The plate ought always to be washed with water and hard-scrubbed after the use of ammonium chloride, which leaves the amalgam surface unclean. The pulp would remove the stains in the course of time, but until such time as it does, the plate is not at its highest efficiency. Should the plate be scoured to bare copper, I see no serious objection to the use of a weak solution of potassium cyanide, as it prepares the plate for re-amalgamation much more quickly than does ammonium chloride. The use of cyanide is considered inadvisable by some, owing to its solvent action on gold, but I am of the opinion that the time saved is worth more than the minute quantity of gold that may be lost.

Further, cyanide solution is said to harden amalgam. If the plate is sprinkled with mercury, and a little amalgam be added, this objection does not hold good. Too much amalgam should not be scraped off, for a closely scraped and rubbered plate is always 'slippery,' and therefore not suitable for catching the gold. Again, as the plates are dressed every eight hours, enough mercury must be added to keep them soft during that period. A clean plate retains less mercury than does one with a quantity of amalgam on it, and thus it either becomes hard before the end of the shift or, if a little more than enough mercury has been added, 'tears' form on the surface and run down into the traps. It is preferable, however, to have too wet than too dry a plate.

Cyanide in Mill Water Kept Plates Bright.—Owing to the shortage of water on one occasion, creek water was used into which about 60 tons of 0·10% KCN solution flowed per day after passing through the waste-extractor box. The return water to the battery therefore contained a small percentage of cyanide. The plates during this period became bright, hard and frosted in appearance. They 'came up' well after the clean-up and, from the point of view solely of cleanliness, the trace of cyanide in the mill water was an advantage. After the first day or two the plates remained bright, although they were not so hard. They were 11 ft. long 4 ft. 8 in. wide, with a grade of 6%. This was too steep for large tonnages, taking into consideration both quantity of pulp and coarseness of the feed. To prevent scouring of the plates, as the result of a broken screen above, a spitzkasten was installed at the head of each branch launder, the underflow feeding three Bigelow amalgamating pans working in parallel.

A stain should be carefully removed and preferably a little amalgam should be rubbed in at the spot where it occurred; otherwise the discoloration commences to 'creep' up to the plate, and so gives rise to further trouble. The light stain sometimes seen on a good plate is easily got rid of by rubbing in a sprinkling of mercury. The splash boards should be kept soft, as otherwise pieces of hard amalgam may break away and pass into the riffles. The layer of amalgam on them should not be thick.

Preparing Old Plates.—Some old plates, which had been scaled, had to be prepared for use. They were scoured with clean coarse sand, wet with strong cyanide solution, and then well scrubbed, after an addition of mercury, until most of the surface had been amalgamated. Soft amalgam was then added and well rubbed in, cyanide solution being used again. After a light feed had been run over the plates for a few days, they were in excellent condition. The plates were dressed on afternoon and night shifts exactly as on day shift, except that the scraping was omitted.

The 'black sand' and iron oxide that collect at the head of the plate should always be removed. If much amalgam is scrubbed up it can be rubbed in at the upper end; if only a little, it may as well be removed with the 'black sand.' It is not necessary to keep a thick layer of amalgam on the plates, for if the surface is spongy with a layer 1/16 in. in thickness, any quantity in excess of this is of no practical value. The mercury used in dressing should be scrupulously clean. Retorted mercury always contained impurities in the form of scum, which was removed by skimming, by pouring the mercury from one bucket to another, by agitating under warm dilute nitric acid and then filtering (the apex of the filter paper was pricked so as to allow minute globules to fall into a solution of potassium cyanide), and finally by squeezing through a double thickness of muslin. A globule of the mercury would now roll down a glass plate without leaving any trace of impurities.

The daily 'scrape' was ground with mercury in a Berdan pan, the iron particles being removed with a magnet. About 60% of the gold in the plate heads was recovered by amalgamation. Fine-grinding was not practised, because it was desired to keep the percentage of slime, which was not treated, as low as possible, and to prevent the liberation of graphite, which caused trouble in the sand cyanide vats. I believe a flotation plant has been installed, and a better recovery is now made, as the graphite is floated off with the concentrate.

Procedure at Monthly Clean-Up.—At the monthly clean-up the plates were steamed for two hours, then scraped and scoured for two hours, six 'boys' to the plates. The scouring was done

with clean sand and 'block,' made by wrapping iron gauze round rectangular blocks of wood. Mercury was added at the rate of approximately 7 lb. every half hour. After an hour's scouring, all the sand and amalgam was pushed to the head of the plate and the sand was washed down into the foot launder, the discharge pipe of which was of course plugged. The plate was rubbered up closely and the riffles were cleaned out on to the plate, which was scoured for another hour and then sluiced down and dressed. Judgment must be exercised in determining the duration of the scouring. It is inadvisable to try for a record clean-up if the setting of a new record spells ruination to the plates; records may be too dearly bought. Personally I considered a 45 min. scour ample, followed by a second scour lasting 30 minutes. Each of the plates yielded 110 to 140 oz. of amalgam. The steamed amalgam was put through the Berdan pans and squeezed into slabs of 500-600 oz. in a mechanical squeezer; all other amalgam was hand-squeezed into 100 to 150 oz. balls, though I think 80 oz. balls are the most convenient for retorting and subsequent melting down.

When the mill stopped for the monthly repairs, the riffles, distributors, launders and traps were cleaned out. Any large pieces of amalgam recovered went to the Berdan pans; the cocoanut mattings were hand-picked and brushed and then stored for burning. All other material went to the barrel for 16 hours' grinding. The slag from smelting was ground for 16 hours; one-half bucket of mercury was then added and grinding continued for four hours more. The barrel, on being cleaned out, usually yielded 10 oz. of amalgam. The slag was dried, sacked and shipped to England.

Roaster Pan Clean-Up.—The buckets of material from the roaster pan were washed under a tap, the large pieces of iron picked out, and the residue was floated in a bucket of mercury, the amalgam sinking to the bottom. The skimming went to the Berdan pans, and after four hours was floated in another bucket of mercury, the second skimming going to the barrel for 16 hours.

When a large bowl of skimming from the daily amalgam had been collected, it was squeezed as free as possible from mercury and put in the Berdan pans for four hours. After the addition of two cups of mercury, the pan was cleaned out into one-half bucket of mercury, any skimming being re-ground for two hours.

The iron that had been 'magneted off' was ground in the barrel for 48 hours, three-quarter bucket of mercury was added, and grinding continued for four hours. The iron was cleaned out and sieved in a tub of water, the coarse and fine particles being 'panned' separately and 'magneted.' One and one-half drums of iron yielded 65 oz. of amalgam. A drum was 2½ ft. high by 1½ ft. in diameter.

Roaster Department Practice. — The plant started with one Edward roaster, side and end fired; the gases passed to flue-dust collecting chambers, and thence up the stack. The concentrates were charged by means of a conveyor into a hopper from which, by means of a screw-feed, they were discharged into a push conveyor at the fire end of the furnace so as to eliminate moisture. No great amount of moisture was, as a matter of fact, removed in the travel of the concentrates along the furnace top; and as the conveyor went out of order rather frequently, thereby causing delay and necessitating the expense and irregularity of hand feeding, I think the plan of feeding directly from the hopper into the furnace is preferable. At about the fourth rabble from the feed end, the charge gives off white fumes and begins to spark; it becomes hotter and hotter as it is worked down the furnace, and the discharge is at a bright red heat. The fires should not be too fierce, for a high temperature causes the charge to clot and thus to receive a bad roast.

Wood was employed as fuel. It is important that the firing should be regular, in order that a uniform heat may be maintained. Later, a new furnace, on the regenerative principle, was erected, the gases passing over the charge and then under the hearth before going up the stack. It had greater capacity, and did better work.

Grinding Followed Roasting.—After roasting, the concentrates (which now weighed 30% less) went to Bigelow pans. The charge was divided equally between two pans, the overflow from the lip discharge of each pan going to another pan for regrinding, making four pans in all. The roasted concentrates were crushed in 0·5% KCN solution, and amalgamation was practiced in the first two pans. At each of these was placed a drum containing a 5% lead acetate solution, the rate of drip being regulated according to the condition of the roast. From the regrinding pans the pulp streams flowed to whichever agitator was being filled. The agitator (12 ft. diameter by 8 ft. high) took about 24 hours to fill, and the charge was then further agitated for 48 hours.

The pulp flowed by gravity to a monteju, and thence by air pressure to a 50 leaf Deline filter press. A cake contained about 163 lb. of dry slime. The charged press was given three washes from the barren solution vat, and two water washes or more if necessary. The auriferous solution from the agitator had a cyanide content of from 0·25% to 0·3%, the drainings from 0·02 to 0·05%. Twenty pounds of lime were added per shift to the roasted concentrates, and the same quantity was thrown into an agitator after it had been filled. About 30 lb. of cyanide in solution was added to an agitator during filling.

The protective alkalinity was kept latterly as high as 0·1% CaO; previously it had ranged from 0·003 to 0·009%, and had given satisfactory results on light feeds. On one occasion after an agitator had been filled, it was noticed that the cyanide content had fallen to 0·02% from the average value of 0·275%. While the agitator had been filling, the roast had been exceptionally poor and both air-lifts out of order. The charge was pressed and the residues, which showed a high assay value, were re treated. Apparently, therefore, as the washing in the press had been thorough, the gold in the charge could not have been dissolved out satisfactorily.

This may have been due to the great destruction of KCN, owing to the bad roast or to the lack of sufficient oxygen in the pulp, which latter delayed the solution of the gold. The rich residues were hand fed into the pans and re-agitated with excellent results. A screen analysis of the roasted concentrates before and after grinding is appended.

Sieve Analysis of Roasted Concentrates.

Mesh.	Before Grinding.	After Grinding
+ 30	5·5	1·05
+ 60	14·1	0·91
+ 90	33·5	3·62
+ 120	6·1	2·70
+ 150	9·6	4·83
+ 200	12·45	5·48
− 200	18·88	81·38

Experiments on cyanidation of the fine dust were conducted with the following typical results. In No. 1, agitation with KCN was employed without roasting. In No. 2, two hours' roasting was followed by agitation with KCN."

Results of Cyaniding Flue Dust.

	No. 1	No. 2.	
Solids in feed, per cent.	25	25	25
Strength of KCN solution, per cent....	0·5	0·5	0·51
Pounds CaO per ton...	50	30	50
Hours agitation ...	24	24	24
Strength of KCN after agitation, per cent.	Nil	0·48	0·5
CaO after agitation, per cent.	0·01	0·112	0·124
Assay value of heads	$44	$41	$44
Assay value of residue	$32	$5·25	$4·60
Percentage recovery...	27·6	88·2	89·7

As O before roasting. 7%; after roasting, trace. Loss in weight during roasting, 17%.

—PAUL T. BRUHL.—*Engineering and Mining Journal*, Feb. 23, 1918, p. 367. (E. M. W.)

Abstracts of Patent Applications.

C16.17. The Dorr Company. Classifiers. 15.10.17.

This application relates to settling and classifying apparatus of the type in which ore-pulp is divided in accordance to the different specific gravities of its solid constituents.

It consists of primary and secondary settling chambers—details of construction being given—which show these chambers to be interconnected by restricted passages which materially increase the efficiency and capacity of the combination.

809.17. D. Zaverdine. Improvements in amalgamating and concentrating apparatus. 2.12.17.

This application relates to improvements in amalgamation and concentrating apparatus, and consists in a vertical trunk or box, fitted with projecting inclined amalgamated plates over which the pulp is passed. Concentration is performed either in the bottom of this box, or others which may be attached thereto, and which are shown in the form of traps with varying kinds of riffles. Other details occur in providing baffles to regulate the flow of pulp, and the optional use of an upward stream of clear water.

67.18. S. E. Hubbard (1), A. E. Barker (2). Improvements in stope and like conveyors. 29.1.18.

This application relates to conveyors of the type made up of a pair of endless ropes or other flexible members passing around terminal drums and supporting one or more load carriers, which are short in relation to the length of the ropes.

According to the design set forth in the application, the load carrier is not fixed to either rope, or may be fixed to one rope, the purpose of this being to overcome the difficulties experienced by differential movement or creeping of the ropes, so as to avoid the distortion of the structure which would eventuate in the case of a creep where the carrier is fixed to both ropes.

The load carrier in this particular case is made up of wooden slats threaded on pieces of rope or other flexible material so that it may pass around the terminal drums.

77.18. N. Y. Robertson (1), H. Moss (2). Improvements in pipe and hose coupling. 1.2.18.

This application refers to a pipe or like coupling, the combination with a socket element providing a socket, a spigot element adapted to pass into the socket and having an enlargement at its front end, a resilient washer positioned on the spigot behind the enlargement, and means to retain the spigot in the socket, said means engaging the back of the washer whereby, upon pressure being established within the coupling, the washer is compressed into contact with the socket.

There are other claims which include a connection on the bayonet principle, and modifications of the original claim, and the claims are not confined to the description.

109.18 and 457.18. J. E. Jones. Improvements in mortar boxes for stamp mills. 26.7.18.

This application relates to a proposed improvement in the construction of the upper neck of the Nissen type of mortar box within which the head travels.

In the present construction of the mortar box the back portion of this neck is an integral part of the main casting, the first portion only being removable.

In view of the wear taking place on the neck, this application provides for its being a separate casting made in halves, the back portion being secured by bolts to the body of the mortar box, and the front portion secured to the back portion by other bolts so that the front can be removed without disturbing the back.

The application further provides for the lower portions of the neck halves—where the greatest amount of wear occurs—being detachable from the upper portions, so that these lower portions may be renewed without having to discard the whole of the neck.

Changes of Address.

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APR 25 1920
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THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

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Vol. XIX MARCH 1919. No. 9

Proceedings
AT
Ordinary General Meeting, March 15, 1919.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 15th March, 1919, Mr. H. S. Meyer (President) in the chair. There were also present:—

24 Members: Messrs. A. Whitby, H. A. White, H. R. Adam, C. Toombs, F. Wartenweiler, G. A. Watermeyer, W. R. Dowling, J. E. Thomas, Prof. J. A. Wilkinson, G. Hildick-Smith (Members of Council), P. Cazalet, J. M. Dixon, L. D. Hingle, Dr. L. G. Irvine, W. H. Jane, A. King, T. G. Martyn, G. Melvill, J. T. Morrisby, H. A. Read, J. Thorlund, C. J. Tutt, J. S. Willcox.

9 Associates: Messrs. E. G. Bilse, J. Boyd, J. Cronin, C. L. Dewar, O. A. Gerber, C. H. Olsson, D. R. Robinson, J. de Villiers, J. Whitehouse.

10 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting held on the 15th February, 1919, as recorded in the February *Journal*, were confirmed.

GENERAL BUSINESS.

ECONOMIES IN MINING ENGINEERING SUPPLIES.

(Printed in *Journal*, December, 1918.)

The President: We are fortunate in having Mr. Elsdon Dew present at our meeting this evening. Perhaps he would like to contribute a point or two for our benefit.

Mr. W. Elsdon Dew *(Visitor)*: I have really come to learn something this evening, and not to try to impart any knowledge. This subject is one that has been dealt with more by the workers on the mines than anyone in the head offices, and the few points I have collected were really with a view to putting these things together for the benefit of the others on the mines, so that they could read them, and thereby possibly impart a certain amount of enthusiasm with a view to the subject being furthered.

I really have very little that I personally can add with regard to the matter. As I have said before, it is really these things on the mines from which we have learnt a lot; the head offices have acknowledged the many points that they can learn from the mines, from the practical experience and practical work done.

The President: The obvious thing for me to do now is to ask any of the workers on the mines to contribute to the discussion, and thus add to our knowledge.

THE HANDLING OF AMALGAM FROM STEAMED PLATES.

Messrs. A. J. Herald and A. King *(Members)*: *Usual Method and its Disadvantages.*—It is common practice in many mills to clean the amalgam from the steaming of plates grinding it up with additional mercury, removing iron, pyrite, etc., in the ordinary way, and then press into cakes ready for the retort. By this method a clean amalgam in a convenient form for the retort pans and containing 27% to 30% fine gold is obtained, the amalgam in the process having taken up an additional 18% to 25% of mercury, practically all of which is of course ultimately recovered from the retort. Where large quantities of steam amalgam have to be handled this method has disadvantages which will be obvious to those acquainted with the operations; several white men, including responsible officials,

are left in the amalgam room continuously for a number of hours, other work and supervisory duties having to be neglected in the meantime, and the labour involved in carrying out the cleaning and pressing of this product is by no means light. There is always a certain amount of risk and danger in having several thousand ounces of amalgam in various stages of the process exposed. The retorting and smelting of this cleaned amalgam present no difficulty, however, bullion of 890 gold fineness being commonly obtained.

Proposed Method.—The method which the authors have adopted after slight variations, is as follows:—The plates to be steamed are made reasonably clean by washing down and removing iron, etc. (by scraping lightly, if necessary), before steam is applied. After steaming and scraping the crude amalgam is introduced at once into the locked receptacle in which it is to be conveyed ultimately to the smelting room, no grinding with additional mercury being done. When charging the retort pans a small quantity of oxidiser (such as manganese dioxide) is sprinkled over the amalgam. The amount of oxidiser used is about one half per cent. on weight of amalgam, and is not enough to cause any ebullition or affect the bullion in any way except to oxidise the iron present in the amalgam so that it may be absorbed readily into the slag as a silicate during the subsequent melting of the retorted bullion. The retorted bullion will probably look impure on account of the iron oxide present, but will yield clean bars of 888 to 891 gold fineness without refining or skimming.

Advantages of Proposed Method.—These are obvious and important particularly when a large quantity of amalgam has to be dealt with at a time. The amalgam has only to be weighed after it is taken off the plate, and can then be locked away immediately, risks of all kinds and danger of exposure being therefore reduced to a minimum. Labour is also reduced, no overtime being necessary even when 10,000 oz. of amalgam are steamed. It is also obvious that a smaller stock of mercury can be kept when steam amalgam does not require grinding and cleaning. Further, since the capacity of a retort for cleaned or uncleaned amalgam is practically the same, a greater weight of bullion is obtained from a retort full of the latter, as will be apparent from figures already given.

If for convenience of handling it be desired to get the amalgam into a coherent cake this may be done by mixing the amalgam with water and then pressing. This involves a certain amount more handling, exposure and time, and to the authors does not seem necessary.

It will be noted that the method advocated here is a simplified form of the older method, and in that respect might be taken as an example of an advance in practice by elimination of certain operations which were at one time considered essential rather than by further elaboration of the method. A parallel case is that of eliminating the risks involved in intimately mixing calcined gold slime with fluxes preparatory to crucible smelting by introducing the slime and flux into the crucible in separate layers.*

While recommending this simplified method the authors do not claim originality for it; its advantages appear so important to them that they consider it ought to be known and adopted generally.

The President: You have no doubt been highly interested by this suggestion out of everyday practice, and I am sure there are one or two of those present, who are engaged in milling, who would like to comment on the matter.

Mr. W. R. Dowling *(Past-President):* I had the pleasure of seeing this note by Messrs. Herald and King before it was read this evening. The authors are to be congratulated in bringing forward an interesting matter connected with our everyday work. They have clearly demonstrated that advances in practice do not always entail additional operations. In this case the elimination of operations, which had become traditional, constitute the advance.

The safe custody of gold and its various products in a reduction works forms not the least important of the duties of reduction officials and workers, and any measure which makes for this end is to be commended. The elimination of all cleaning operations whereby gold amalgam is exposed for hours and the reduction of operations to the simple scraping and transfer to a locked iron box of the steamed amalgam is a relief from anxiety that must appeal to any reduction man.

The President: This matter will be held over for further discussion at our next meeting.

*See this Journal, Vol. vii., Jan., 1907, p. 212.

CHEMICAL ENGINEERING.

By J. A. Wilkinson, M.A., F.C.S. (Past-President).

The title of this paper makes use of a term which has crept into scientific literature during the last thirty years, and has now obtained by common usage a definite and specific meaning. The reason for this lies in the fact that the development of chemical industry and the progress of chemical technology and applied chemistry have been so enormous as to make demands for a study of that specific kind of engineering and chemical knowledge which is required of those who are called upon to carry out chemical reactions and operations on a large scale and from a commercial standpoint. It will be obvious that the definition just given embraces metallurgical engineering as well, but the vexed and oft-debated question whether this is, apart from its admitted magnitude and importance, of such a degree of differentiation as to be entitled to be classed apart I shall not attempt to discuss, since, whatever answer is given, it must be conceded that the work of both deals with chemical and physical problems of a complex and different character, and it is in the interests of progress that each should be cognisant of the work of the other. The purpose of this contribution is, then, to consider the subject of chemical engineering more particularly from the point of view of local requirements and needs, together with the provision at present made and necessary for its future development.

The experiences of the last four years have brought into great prominence the part the chemist and chemical engineer play in the national welfare. To take one instance only, the fixation of atmospheric nitrogen by uniting it with hydrogen and oxygen has intensified on the one hand the production of foodstuffs, and on the other of explosives, having enabled our enemies during the war to render themselves totally independent of the Chilian nitrate fields, whence formerly these supplies could alone be drawn, and thus to continue the struggle to a period which previously would have been utterly impossible. The manifold activities of the chemist and chemical engineer during this period have served to open the eyes of the public to an extent such as could not have been achieved in so short a time by any other method, and at the same time they have served to weld the profession into closer union with a wider outlook. These facts are the legacy of the strenuous period through which we have now passed, and they will form the foundation stones for that future reconstruction which has been heralded forth so loudly in the daily press. This has recently been stated in other words with particular reference to this country thus:* "Into all the factors which could enable the oversea manufacturer to undersell South African products in the South African markets it is not our purpose here to enter. What we do wish to drive home is this, that no matter what the other conditions may be, there is one great idea, which has firmly gripped the world, and that is, that the days of haphazard production, unaided by scientific investigation, are past. Henceforth the country that ignores the scientist and his laboratory, mentally relegating them to the cloistered precincts of the college and the university and forgetting their very existence, will simply be numbered amongst the "also rans." Other things being equal, the race will be to the manufacturer who joins hands with the scientist, and who not only accepts all the help the latter may offer him, but invites his assistance wherever possible."

This statement was made for the benefit and enlightenment of the South African manufacturer, who will look to the colleges and universities of this land to supply him with the necessary assistance, and this must be of such a character as to enable him to meet the competition mentioned, in other words, he requires not only the chemist or the engineer, but preferably that combination connoted by the term, which may be new to many, namely, the chemical engineer.

The present development of chemical industry in this country is small when compared with that of some of the older civilised countries of the world, but, on the other hand, though not insignificant, it is yet capable of being increased enormously. A glance at the list of imports into this country, many of which could be manufac-

*Vide "S.A. Journal of Industries," Vol. I. No. 16 p. 1482.

tured from our own raw materials, is sufficient to emphasise this point, with which I have dealt fully elsewhere.† That this increase in development will surely take place is a popular belief, but to meet the competition of the imported article it must be effected by the means employed elsewhere, not the least of which is efficient scientific service.

Much has been written of the training necessary to give the chemical engineer a proper equipment for his life's work, and opinions vary enormously, even amongst those who might be expected to have arrived by experience at more or less definite and common conclusions. This arises, I think, from the extreme diversity of the many branches of chemical industry and the fact that what is a most important factor in one branch is of secondary or subsidiary importance in another, and the chemical manufacturer naturally tends to magnify those points by which he has been impressed in his own particular industry. Within certain limits, however, there is a general consensus of opinion as to the subjects required and the time which should be allowed for their prosecution whilst at college or university, assuming that the student enters with the passport of that sound general education which is considered necessary as a foundation for the various learned professions. The latter is work which is generally carried out in the secondary school, and my experiences lead me to believe that specialisation at this stage is fraught with danger. On the other hand, the schoolmaster is subjected to so many critical assaults from all sides, that it is impossible for him to meet all the demands made, and in his attempts to be of the greatest good to the greatest number he often fails to achieve that which experience shows would be the best for his pupils. The difficulty often arises from the number of different university examinations for which he must make preparation, and this is intensified by the number of professional and other organisations, each of which without regard for what exists, demands special work and training for its own specific entrance examination. As a case in point may be mentioned the fact that, in addition to the matriculation examinations of all the new universities in Great Britain, most of the professional societies conduct their own entrance examinations, which resulted in much hardship to students and bewildering confusion to educationalists, so much so that a committee was appointed by the Government, just before the war broke out in 1914, to investigate the possibility of one examination, to be held by the State, which would serve as a common entrance to all universities and professions. In South Africa there is, happily, such an examination in the Universities Matriculation, which if rightly constructed in the near future should obviate any future difficulty in this respect, and at the same time serve as a substitute for those abroad, should the student desire to take his course at other institutions. Professor A. K. Schwartz, in discussing the question of specialised entrance examinations for university or college courses of study in engineering science with a view to the curricula to be followed, and also to the inclusion in the latter of courses in modern languages, at a conference held in June, 1911, at the Institution of Civil Engineers, London, summed up this aspect of the question as follows‡:—"It appeared particularly necessary in the case of the engineer that his secondary school training should be on as liberal lines as possible, since his subsequent training in the college, the workshop and the office was largely materialistic. What was wanted in the engineering courses was a supply of students with a wide mental outlook, whose faculties had been well trained and evenly developed, and any specialisation in the secondary school at the expense of this liberal training was to be deprecated." This opinion is one to which, I think, most of us would subscribe without any hesitation, and upon this foundation is given the specialised training necessary for the practice of the profession.

There is but little divergence of opinion about the subjects which are required in such a course, but, on the other hand, there is much concerning the manner and method of its prosecution, more particularly in the final stages of the work. In a more or less complete sense engineering may be defined as applied physics, and if the field lies in the manufacture of chemical products, then the science of chemistry, both fundamental and applied, must be studied side by side and in conjunction therewith along with the mathematics necessary in both cases. Other studies may be reckoned as subsidiary to these main lines, each desirable in itself as

† "S.A. Journal of Science," Vol. XIII, Oct. 1916, pp. 79-96

‡Report of the Conference: Reprinted from the *Times*, July 5, 1911, p. 17.

a branch of knowledge, but only permissible as serving as a useful adjunct to the central scheme.

As a practical illustration of the method of carrying out such a course, the following is taken from the Calendar of the South African School of Mines and Technology, which is the only institution of university rank in this country which has hitherto attempted to deal with this problem. In the first year the subjects are Pure Mathematics, Applied Mathematics, Physics, Chemistry, Drawing and Workshop Practice, and this work is common to all branches of engineering study, including civil, mechanical, electrical, mining, metallurgical and chemical. In the second year the subjects of study are Pure Mathematics, Applied Mathematics, Physics, Chemistry, Geology, Mechanical Engineering and Drawing, this course being common to mining, metallurgical and chemical engineering students. The third and fourth years are special courses, the subjects for the third year being Chemistry, Chemical Technology, Mathematics, Mechanical Engineering, Engineering Design and Drawing, Electrotechnics, Mineralogy and Crystallography, Metallurgy and Surveying; and for the fourth year Chemistry and Chemical Technology, Metallurgy and Economics. In addition to the above, first year students are expected to make themselves proficient in one modern language at least, and in the second portion of the fourth year the student is expected to engage in research work of a technical character, the results to be embodied in a dissertation which is required before he can obtain his final degree.

Those who are interested in working out more fully the details of the courses mentioned above are referred to the School Calendar. At the same time a useful and thought compelling comparison may be instituted between the courses given here and those laid down by a modern School of Technology such as the Massachusetts Institute with its multitude of teachers and wealth of equipment, the provision of which solves many of the ever present difficulties associated with the presentation of such a course in poorer centres. The purpose of the course amplifies the definition given above and may be quoted here: "To prepare students capable of filling the demand for men competent to build and operate manufacturing industries based upon chemical principles. The efficiency of any industrial chemical process depends not only upon a knowledge of the chemical reactions forming the basis of the process but also upon a knowledge of the mechanical principles on which depend the design, construction and maintenance of plant for carrying on these reactions."

Generally speaking, in addition to the subjects ordinarily included in college courses, the special requirements for this course may be summarised as follows:—

1. The materials of construction used in chemical plant, methods of working and testing them, their commercial forms and cost, and the chemical action of acids, alkalis, etc., etc., upon them under varying conditions of temperature and pressure.
2. The plant used in chemical operations, *e.g.*, drying, mixing, separating, washing, scrubbing, absorption, solution, liquefaction, filtration, evaporation, concentration, crystallisation, comminution, melting, moulding, nitration, calcination, combustion, sulphonation, reduction, etc., etc.
3. The generation of power by gas, steam, electricity, etc., the measurement of temperature, power and efficiency of operation. Distribution of power.
4. Economics of production and effect of legislation thereon. The planning, erection and organisation of industrial plants. Handling and transport. Social service.

The presentation of such a course as outlined above makes very exacting demands not only on the instructors, but also on the institution where that instruction is given. In the first place the equipment of the chemical, physical and engineering laboratories must be complete in order to provide for the needful training in these fundamental subjects, and in addition a laboratory is necessary for the special work of chemical engineering. The primary object of the latter should be the provision of apparatus for carrying out chemical operations on a small scale, where the gram of the chemist could be converted into the half ton or ton of the industrial process. It would be impossible and at the same time unwise to attempt more than this, since experiments on this scale, if executed properly and with a due regard to all the conditions affecting the process, are educative in the strictest sense and give the student a true insight into the requirements of the factory.

The problem of equipment in this case is fundamentally the same as that which professors of engineering subjects have had to solve when equipping laboratories for practical work in their own branches, and those who have had the privilege of studying some of the best engineering laboratories in Great Britain know full well the manner of its solution, namely, the provision of small scale apparatus carefully designed to illustrate fully the principles of the subject and methods of working such as are found in the largest factories and establishments. In designing a laboratory for this purpose the construction of the building requires the most careful consideration owing to the many and varied operations which are carried out. Roof trusses and vertical supporting pillars require to be designed of sufficient strength to allow flexibility in the use of shafting for power transmission, pipe lines or hauling and platforms for the support of tanks and apparatus at various heights. At the same time attention must be given to the materials of construction, more especially of roof and floor with regard to the chemical action of gases, vapours and liquids upon them. In the equipment of the laboratory the first necessity is a liberal supply of power sufficient to meet all requirements and at the same time leaving a large safety factor, which means the installation of steam plant, gas producers and electric motors. Steam and electricity are also necessary for other purposes, such as control of temperature, drying operations, electrolytic and electric furnace work, etc. As these requirements are also necessary in other branches of engineering, duplication should, if possible, be avoided and arrangements made to meet the obvious difficulties which will arise in the absence of a large safety factor. Each should be fully equipped with apparatus devised to secure complete control and measurement of the power used in any given operation, a factor too often neglected even in works practice. In designing the equipment necessary for the chemical operations to be carried out the first point to be decided is the unit of treatment, which must obviously be an approximation, but in an experimental laboratory should be about one ton. In the second place special attention should be given to those nascent industries which are possible and of the most importance in the immediate environment. In the third place the most general types of plant necessary for the individual operations required should be installed in such a manner that they can be assembled and utilised as specific portions of an industrial process in which they are required, and, lastly, especial attention should be given to quantitative measurements, not only over the process as a whole, but in each unit and at each stage.

It is impossible under the ordinary conditions obtaining in colleges and universities to attempt to duplicate factory conditions in a greater degree and at the same time unnecessary, since the complete conditions of any particular industry can only be learnt in the actual factory or works where the commercial manufacture is being carried out. Practice in this phase of the subject can be given by experience in works between the college sessions, a plan which I have adopted in training students here. In fact no other course is open if a chemical engineering laboratory is not provided, but even with the best equipment a college laboratory can provide, the experience gained by students employed in works during the course of their college education is a factor which cannot be overlooked or lightly put aside, and a word of praise is due to those firms here which have been of such great assistance in this way. On the other hand, it should be borne in mind that employers who grant these privileges to students are in a better position, when selecting graduates for employment, than those who have had no such experiences.

The final test of the academic training is, as has been stated above, the solution of some industrial problem involving, if possible, not only scientific but also economic study, and the presentation of the work done in the form of a dissertation for the degree. Work of this nature is, in my opinion, on the one hand a fitting finale to a college training, and, on the other, a meet and proper introduction to a chemical engineering career, as I know of no other method which is equally efficient in bringing before a student the real nature of the work he may and probably will be called upon to do. It is at the same time a proof of the value of his training and a method by which the student himself can gauge his own powers. It assists him to a knowledge of the meaning of research, and should enable him to tackle problems, which he is sure to meet with in his later career, with greater confidence than he might otherwise possess. It is the last step of his tutelage,

and though he may not be aware of it, perhaps the most important. Guidance and counsel are still his for the asking to assist him in the prosecution of the work scientifically and systematically, and whatever the result, the experience thus gained should prove invaluable.

This method of training is by no means new or novel, but in South Africa the fetish of examinations and examinations alone as final and conclusive tests is still to a large extent worshipped, and the sooner the universities of this land adopt an up-to-date policy in this direction, greater and more lasting good will from every point of view be achieved.

The above outlines a course of four years' training, and though I am fully aware that it may have its deficiencies, yet, on the other hand, I venture to think that it includes all that can justly be claimed as being essential. Its aim and object is not to provide specialists for any particular industry, but to give a foundation which will enable men who intend to engage in industrial chemical work to become specialists later by applying their knowledge to the solution of the specific problems of the particular industry they have chosen. In a recent article** entitled "A Manufacturer's Experience with Graduate Chemical Engineers," the writer, Mr. S. R. Church, states that during the past two years he has employed in the general manufacturing department 100 student engineers, who were employed not at first to occupy a definite position, but to undergo a course of study in the company's business and to fit themselves for positions in the engineering, operating or experimental departments of manufacturing after a period of at least six months' training. During this training period the men receive instruction in the form of lectures on various products and processes by heads of the manufacturing and technical staff, and are given special assignments for personal study of a product, process, manufacturing unit, laboratory or works experiment, etc. At the end of this period the student is assigned to a definite position or released, or under certain conditions continues his probationary period. The experience gained is summed up by the statement "That a comprehensive course of chemical engineering should cover at least five years, and preferably six, which will probably not be realised owing to the tremendously increased demand for chemical engineers." At the present moment, and indeed for some years to come, I doubt if it would be possible in this country to add a fifth year of college study, but this might be achieved by a post graduate year, in which the student would be engaged in research on some industrial problem. There are many manufacturers who are either unable or unwilling to retain the services of a chemist or chemical engineer, but who, on the other hand, have problems which are in urgent need of solution. The colleges of the country can aid in this respect by placing the services of their laboratories, staffs and graduate students at their disposal, for which privilege the manufacturers would be called upon to pay an amount not exceeding a certain sum to be settled in consultation with the college or university authorities.

This scheme, which is practically the same as the Industrial Research Fellowships first proposed and carried out by the late Professor Kennedy Duncan in America, would inevitably lead to that desirable and mutual understanding which ought to exist between the colleges and universities on the one hand and manufacturers and leaders of industry on the other. In America the results have been of the utmost value, and eventually led to the establishment of a special centre for industrial research, the Mellon Institute at Pittsburg, where every facility is granted both to the industrialists and research graduates from the various colleges and universities of the country; and, be it not forgotten, this in a country where endowments for educational purposes are forthcoming in bounteous plenty, not merely from the State, but from private individuals, who consider it a privilege and an honour to associate themselves with these good works for the upliftment and progress of the community at large. A modern educational institution must keep ever before its eyes the needs of its environment, and, in my opinion, as far as chemical industry is concerned, there are few better methods than the one outlined above.

In conclusion, it may not be considered out of place to refer to the investigations undertaken in the U.S.A. by the Joint Committee on Engineering Education of the National Engineering Societies and the Carnegie Foundation for the Advancement of Teaching into those qualities, which spell

** "Journal of Industrial and Engineering Chemistry" Dec., 1918, p. 1019.

the success or failure of a college graduate in his professional career. A committee appointed by the Council of the American Institute of Chemical Engineers, with Professor Withrow as its present chairman, is in charge of this investigation with especial reference to chemical engineering work, and its object is to render assistance to those who are responsible for the preliminary training of students, and, in the second place, to employers when selecting men for employment or promotion.

The first step taken was to circularise the members of the societies individually with a request for answers to the following questions:—

1. What are the particular points at which the work of the engineering schools is effective and successful?

2. What are the particular points at which the work of the engineering schools is *least* effective and successful?

3. What specific experiences illustrate the conclusions expressed in your answers to questions 1 and 2?

4. What are the most important factors in determining probable success or failure in engineering?

5. When examining a candidate for a prospective job, what sort of information is best calculated to assist in judging his fitness and probable success? Give samples.

6. What sort of work, what specific jobs, what kind of experiences are most effective in testing a man for fitness and probable success in engineering? Give samples.

7. Have you ever found a knowledge of either French, German or Spanish essential to your professional career?

8. Should a reading knowledge of one of the modern languages be required of every engineer? Why?

9. Make specific suggestions for the improvement and strengthening of the engineering schools.

Unfortunately out of 21,815 circulars sent out only 1,400, or 6·4%, were returned, rendering it impossible to form an opinion which could be rightly considered as a true reflection of the opinion of the engineering profession. Notwithstanding this, the replies were summarised and divided into eighteen groups, each descriptive of an important element in the education of an engineer. The knowledge thus gained was made the basis of a further enquiry, and in order to elicit further information a circular was sent out again asking members to number in order of importance for success in engineering the following, which was compiled from the replies sent in by the 1,400 engineers to the previous circular, as being the fundamental factors for determining the success of young graduates:—

TABLE A.

(*a*) Character, integrity, personality.
(*b*) Self-reliance, responsibility, perseverance.
(*c*) Ability to understand and handle men.
(*d*) Initiative, originality, resourcefulness.
(*e*) Judgment, commonsense.
(*f*) Industry, energy, willingness to work.
(*g*) Technical knowledge.
(*h*) Scientific attitude, reasoning power, open-mindedness.
(*i*) Accuracy, care for detail, thoroughness.
(*j*) Executive ability, efficiency.
(*k*) Business training.
(*l*) Breadth of view, general education.
(*m*) Ambition, enthusiasm, interest.
(*n*) Power of expression.
(*o*) Morality, patience, modesty.
(*p*) Application of theory to practice.

To this circular the response should be generous, since the labour and thought involved in completing it is reduced to a minimum, and the views of the profession as thus expressed will be of the utmost value to succeeding generations, since it will reveal deficiencies in training and enable those responsible to remedy these as far as it is possible to do so. At the same time, however, no college, university or school of instruction of any kind claims to perform the function of a universal provider of the endowments requisite for success. What it does attempt is to assist its protegés over what is perhaps the most difficult chapter of their life's work.

It is a well known fact that it is by no means uncommon to find successful managers and leaders of industry, whose training has been obtained entirely in works, factories or mines, and it will be a matter of great interest to compare the replies of those who have experienced the rough and tumble to those returned by their contemporaries, who have enjoyed a college education. A knowledge of the many difficulties which beset the former in their struggle for superior positions has generally resulted in a strong affirmation of the benefits to be derived from an academic training and indeed active participation in modern chemical industry makes demands which cannot be met without it.

The college student, on the other hand, owes himself the duty of looking ahead into the future, and, if possible, trying to discover the rôle he would like to play. Some are capable of doing this, others are misfits preparing for a career for which nature never intended them but still possessing the necessary ability to meet prescribed examination tests and other requirements, whilst lacking at the same time that true mental perception required for correct adjustment to their proper environment.

Though the enquiry is being conducted for the betterment of the conditions as they exist at present in the universities and colleges of America, yet there is much that is appropriate elsewhere. The quickening and progress of chemical industry in South Africa assuredly must create the demand for men trained in chemical engineering. They will be called upon to perform great tasks, and it will be their privilege and duty to see that they are greatly performed. Self-knowledge and self-criticism are capable of being forged into mighty levers of assistance, and action will soon discover their truth.

The following references will be found of interest in connection with the foregoing:

1. Presidential Address: Society of Chemical Industry, London, by Sir G. T. Beilby. *Journal of the Society*, Vol. xviii., pp. 333-340: Discussion, pp. 437-443.

2. The training and work of the Chemical Engineer: Discussion, Faraday Society: *vide Journal of the Society of Chemical Industry*, Vol. xxxvi., March 15, 1917, pp. 276-278.

3. A Handbook of Chemical Engineering, Vols. 1 and 2, by Geo. E. Davis; 2nd edition, 1904.

4. *Transactions* of the American Institute of Chemical Engineers:

(*a*) Reports of the Committee on Chemical Engineering Education:
Vol. ii., 1909, p. 24.
Vol. iii., 1910, p. 122.
Vol. iv., 1911, p. 218.
Vol. vii., 1914, pp. 18 and 40.
Vol. ix., 1916, p. 23, *et seq.*

(*b*) Remarks on Chemical Engineering, Vol. iii., p. 151.

(*c*) Development of the Chemist as an Engineer, by F. W. Atkinson, Vol. iii., p. 153.

(*d*) The training of Chemical Engineers which meets the requirements of manufacturers, by M. C. Whitaker, Vol. iii., p. 158.

(*e*) Teaching Industrial Chemistry, by A. H. Sabin, Vol. iii., p. 169.

(*f*) The Study of Materials in Chemical Engineering, by C. F. McKenna, Vol. iii., p. 108.

(*g*) The Four Year Course in Chemical Engineering, by J. H. James, Vol. iv., p. 231.

(*h*) The Question of Five Year Engineering Courses at Ohio State University, by J. R. Withrow, Vol. iv., p. 238.

(*i*) A Course in Chemical Engineering Education, by J. C. Olsen, Vol. iv., p. 250.

(*k*) The New Chemical Engineering Course and Laboratories at Columbia University, by M. C. Whittaker, Vol. v., p. 150.

(*l*) The Chemical Engineer and Industrial Efficiency, by W. M. Booth, Vol. v., p. 184.

The President: I am perfectly certain that you have listened with the greatest interest to this highly elaborate paper by Prof. Wilkinson, who is not only a scientist, but also an educational expert. He has told us how to make the "complete engineer." To me, his views are somewhat idealistic, because he has suggested equipment and arrangements in an educational institution which even very few of the most specialised factories and industries would ever dream of installing.

As regards the wisdom of such a policy, that is another matter; but I think he is laying out a programme which many people, no doubt in their ignorance, hitherto have failed to realise, because they have not understood the value. Although he has called the subject of his paper "Chemical Engineering," that merely is because his bent is possibly in that direction, but it applies, to my mind, equally well to any other branch of engineering with which we in South Africa have to deal. He has also left out rather the producer of the raw material. He deals undoubtedly with the manufacturer and the handling of the product which is placed in his hands for marketing; and I venture the opinion that all the views he has expressed and all the suggestions he has made apply equally to the dirty end of the job, which is the production of the raw material.

I, unfortunately, have not had the privilege of reading the paper through, so my remarks on it naturally must be very sketchy; but there was one point he made, and that was the fact that examinations held a rather more prominent position in the valuation of a man than is necessary. At the same time, he explains that examinations made in a more intelligent fashion are really a very highly important test of a man's abilities. He must, nevertheless, not overlook the fact that there is the old-fashioned prejudice that a man who is in possession of decent examination certificates is always known as a theoretical man. I am told that kind of prejudice can be

removed. Examinations, however scientifically conducted, will always, in a purely practical district, carry a certain bun. I do not wish to make any more remarks at present, except to propose a very hearty vote of thanks to the author for his highly valuable paper.

Mr. P. Cazalet *(Member)*: I came here to-night, not only as representing to a limited extent the employer's interest, but also as the father of growing sons who may have to sit under Prof. Wilkinson or others of his colleagues, and I am particularly glad that that purpose did bring me, because Prof. Wilkinson's paper is especially interesting as indicating the application locally of the ideas which have been moving people all over the world, towards improving the engineering training of the youth of all countries.

I quite agree with Prof. Wilkinson in the curriculum, which he has outlined roughly, that is being taught to boys here; but I would like to suggest a danger that might happen if a boy is attempted to be made too much a "Jack of all trades and master of none"; we must not expect boys who are taught to become chemical engineers to be not only first-class practical and theoretical chemists, but also engineers capable of designing and even supervising the manufacture of their own plant: I believe if the idea of the combination of the two branches of engineering is carried too far the danger will come of those men not being real experts in their own particular line. At the same time, any chemical engineer, to be really successful in chemical manufacture, in this country at least, should, I think, have sufficient knowledge of the other branches of engineering to be able to see that he has got good work produced by the people employed to do his designing or to supply his plant; I have heard it suggested and have read in papers on the subject that the chemical and engineering student should be made capable of supervising the designing and making of *all* this work himself, but I do not agree with this view. Probably the large proportion of the youth of any country would fail either in the capacity or the application to make it possible for them to become really experts in *all* the different branches of engineering included in their training; and, as long as this fact is recognised, then the training of the chemical engineer, or the engineering chemist—and I have seen subtle distinctions drawn between the two where small difference seems really to exist—will be carried forward on right lines. As long, that is, as those men are grounded in all the different arts which may affect their work and then specialise in the one to which they are best suited, they will have their best chance of success; and I am very glad to hear that our university *in posse* is already catering so fully for the development in chemical and other industries which can be foreseen here in South Africa.

Dr. W. A. Caldecott *(Past-President)*: Our Society is to be congratulated on having presented to it a paper on a subject so closely connected with the development of this country's natural resources. In the past in England systematic training in this branch of knowledge has been much neglected, although it is essential in chemical manufacturing and many other industries, such as some metallurgical processes, explosive manufacture, and the soap and fat industries. It comprises both chemical and mechanical knowledge, and deals with the materials, appliances and processes involved in the conduct of chemical reactions upon a commercial scale. Hence its importance is great, and it serves to enlarge the scope of chemists beyond analytical work, by assisting to fit them, after having obtained sufficient practical experience, for the more responsible position of control of factories and works. In the present stage of South Africa's industrial development, as in other countries, the demand for men with such training should increase.

As has been pointed out by Sir William Ramsay,* the chemical student in England is "for the most part well taught so far as scientific chemistry is concerned. . . . But at the end of his four or five years' training, when he has probably graduated, and has been awarded a degree, or a diploma showing that he is an associate of the Institute of Chemistry, he is almost always woefully ignorant of the properties of the materials required to carry out operations on a large scale, which are perfectly familiar to him on the laboratory scale, when glass and porcelain and platinum, water pumps and mercury pumps are available. The most that can be expected of him is that he shall have a fair knowledge of the science, and that he shall have some notion of how to tackle a new problem.

*Preface to Grossman's "Elements of Chemical Engineering, 1906.

It may be said that in Britain there is, for the most part a gulf fixed between the technical and the scientific chemist; a gulf which our Continental competitors have managed to bridge; for abroad it is by no means infrequent for the technical chemist to become professor, or *vice versa*; and works problems often find their solution in University and Polytechnicum laboratories, while the facilities of the works are often extended to the scientific chemist. And abroad, the works afford a training school for scientifically trained chemists, such as are practically unknown in England."

It is hence appropriate that a forward step in this direction should have been pointed out to us by a representative of the University of South Africa, and I understand that the University of Cape Town is also considering a course of instruction in chemical engineering.

The author has furnished a bibliography of the somewhat scanty literature on this subject, but I may be permitted to draw special attention to an article in the *World's Work* for January, 1919,* and also to Prof. F. G. Donnan's views,† which are as follows:—

"There were three broad lines upon which to train a man for future work in connection with chemical processes in the factory, viz.: (1) thorough and extensive chemical training, with a certain amount of training in engineering; (2) a pretty extensive training in both chemistry and engineering; (3) a further study of chemistry for those who have received or are receiving a thorough training in engineering. Method (1) produces the chemist (research chemist), method (2) the engineer-chemist, and method (3) the chemical engineer. . . . In chemical engineering there lies the greatest and most lucrative field of development for engineering science, and schools of chemical engineering should be founded without delay."

Although a society of Chemical Engineers exists in the United States, I understand that an early attempt to form a similar body in England failed, but of late (31st December, 1918) the Society of Chemical Industry decided to form a Chemical Engineering Group for the special study of:—

(*a*) General design and lay-out of chemical works.

(*b*) Power generation and transmission plant in chemical works.

(*c*) Operations or process plant in chemical works (the operation or process not necessarily involving chemical change).

(*d*) Plant for carrying out chemical reactions.

(*e*) Special plant for primary chemical industries (*i.e.*, for the direct utilization of natural raw materials).

(*f*) Special plant for secondary chemical industries (*i.e.*, for the utilization of artificial raw materials).

(*g*) Professional and miscellaneous matters.

While the chemical engineer of the future may be a chemist with some knowledge of engineering, or *vice versa*, I think both types will exist, but that radical advance is more likely to be expected from the former, excellent though the latter may be for the routine conduct of operations. Apart from the knowledge gained, the introduction of training in a chemical engineering laboratory, as outlined by the author, should have a most desirable effect in bridging the gap between theory and practice, and in enlarging the mental attitude of the student by rendering him able to think in hundredweights and tons as well as in milligrams and grams, and likewise to realise that a simple operation in the laboratory may call for entirely different apparatus, varied according to conditions, to ensure efficient and economical work under practical large scale conditions.

Another very useful function which the chemical engineering laboratory suggested by the author would serve is in the investigation of the properties and products of comparatively large parcels of raw materials, such as natural crude saline mixtures, and vegetable products yielding dyes, drugs or tanning extracts. Just as various metallurgical investigations have been carried out in the metallurgical testing plant of the S.A. School of Mines, so a chemical engineering laboratory would serve to determine the applicability of standard or proposed manufacturing processes to many South African raw materials, and the results obtained and observations made during the test would go far to ensure the appropriate design and operation of plant subsequently erected in a factory.

Such work would give concrete evidence of the value of investigation or research by

*See this issue of the *Journal*, pp. 101-2.

†"Journal Society of Chemical Industry," 15th March, 1917, p. 276.

men with scientific training, and help thus to demonstrate to those financially engaged in industrial enterprises that future progress calls for such inducements being offered as will serve to attract young men of capacity and energy to undergo the necessary training for this work. At the present time, apart from the gold mining companies, the remuneration to scientific and technical men in South Africa is rarely such as to be attractive, when compared with the material rewards obtainable by other careers in life.

NOTES ON ECONOMIES IN HAND DRILL STEEL.

By H. A. Read (Member).

The following table shows the average number of natives employed on the Witwatersrand in hand drilling, the issues and value of hand drill steel, etc.

Year.	Average No. of natives working	G.M.E.'s Report Issues of Steel, lbs	Issues per native per annum lbs.	Total Value £	Value per native per annum. s.	d.
1913 ..	43,932	4,452,150	101	60,027	27	4
1914 ...	38,570	3,991,061	103	53,350	27	8
1915 ...	49,140	4,538,676	92	64,767	26	4
1916 ...	54,941	4,018,323	73	75,697	27	7
1917 ..	41,836	2,514,158	60	56,409	27	0
Total's & Averages	45,684	19,514,368	86	310,250	27	2

It will be noted from the above that during 1917 considerable economy was effected, due probably to the greater care paid to the conservation of steel and the welding up of short ends.

Consideration of the large sums involved in these issues of steel led to examination of the losses, which are hereafter referred to in detail.

It appeared that one of the principal losses was due to the shanking of the steel under the blows of the hammer, and this in turn led to the conclusion that if shanking losses could be prevented by means of a permanent drill head an appreciable economy would thus be effected. After some experimenting the solution of the problem was found, as it was ascertained that by heating the end of the drill and staving it up (either by means of a die and dolly in a Leyner Press or by hand) so as to give the head of the drill a bulbous or pear shape and subsequently tempering it, the drill would be provided with a head capable of resisting hammer blows without shanking.

The question will be asked why the new form of drill head stands up to the work. The explanation appears to lie in the fact that the head is so staved-up that the least possible disturbance is created in the first instance in the molecular formation of the steel. Correct draw tempering then clothes the bulbous shaped head with a fine coating of hard tempered steel—probably not much more than 1/16 in. thick, below which is a body of lower tempered steel. This body of lower tempered metal (increased as it is beyond the original section of the drill) provides a re-inforcement which prevents the disturbance and disintegration of the molecules of metal which otherwise take place under impact of the hammer.

A sketch of the die and dolly used with the Leyner Press to make the new type of

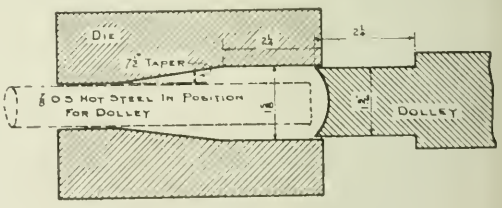


Fig. 1.—Die and Dolly.

drill is reproduced (Fig. 1), also a rough sketch of the tools for use with the steam hammer, and for hand finishing.

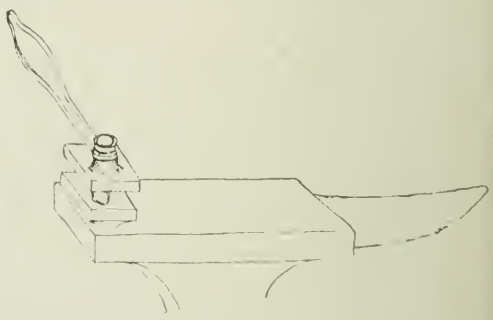


Fig. 2.

Fig. 3.

Fig. 4.

The advantages of the new form of drill head are as follows:

(1) The saving of steel by preventing crushing or "mushrooming" of the shank end.

(2) Elimination of danger to natives, as there are no splinters or jagged ends.

(3) Improved drilling, as the natives have a uniform tempered surface to strike, and the energy hitherto absorbed in shanking is diverted to the work of drilling.

(4) Improved control of steel. The drill heads are practically permanent, and, as the starter becomes too short, the permanent heads can be welded on to other steel.

There would be no excuse for these shaped drill heads to be found lying about. A mine once fully equipped should require enough steel only to make good the *bona fide* wear through drilling and sharpening.

(5) The drill instead of being a ragged-ended piece of steel becomes a workmanlike tool well suited for the job which it has to perform.

(6) The cost of trimming up and periodic retempering of the old form of drill by lead bath or other method (where such is the practice) is saved.

I shall allude later in some detail to the results of the experiments tried with this drill, but for the moment will pass to a brief examination of steel consumption and losses.

The consumption of steel may be classified under the following heads:—

(a) Steel actually worn away in process of drilling and lost in sharpening.

(b) Steel worn away by hammer blows on the shanks or heads of the drills.

(c) Short ends discarded.

(d) Drills lost in the mines.

Dealing with these losses in rotation:—

(a) *Steel actually worn away in drilling and sharpening.*

This is a legitimate consumption. The rate of loss depends upon the system of sharpening used (hand or machine) and even, in the latter case, on the type of sharpening machine used. The determination of the respective losses in sharpening by hand and by different types of machines is a matter requiring further investigation.

(b) *Steel worn away by hammer blows.*

The tendency is for steel to crush or "mushroom" under the impact of the hammer. Various methods of tempering have been tried for years past, but the general experience seems to have been that tempered drills are inclined to splinter, and are promptly discarded by the natives owing to risk of injury. Manufacturers have also tried in the past to solve this difficulty and special tempered steel cut to proper lengths has been imported, but without success.

(c) *Short ends discarded.*

As the drills gradually wear down they become too short to use even as starters. A very considerable quantity of short ends has in the past been discarded, and although latterly the tendency has been to economise by welding up these short ends—it is questionable whether this economy has been adopted to the fullest possible extent.

(d) *Lost Drills.*

In the absence of systematic control a considerable amount of steel is liable to be lost. For this there is no justification. Control of all hand drill steel can be secured by the adoption of steel cabins underground and of means for interlocking with the time-keeping system by which reference to a native's ticket discloses whether he has received his jumpers, and whether he has returned them. The native's ticket is punched when he is given his jumpers, and again punched when he brings them back. In the absence of the second punch-hole he is refused steel the following shift and must find the drills he has lost. This system is described in detail later.

Attached (Annexures "A" and "B") will be found particulars of certain experiments which have recently been conducted at the Ferreira Deep, Limited, and East Rand Proprietary Mines, Limited, with the improved form of drill head.

The salient points of the experiments referred to are as follows:—

(1.) *Ferreira Deep, Limited.*

The drilling and sharpening losses per set of three drills (hand sharpened) were

observed to be 0·737 lb. per set of three drills in 34 shifts, or 6·75 lb. per set for 312 shifts.

The loss through "mushrooming" or crushing of steel was 1·927 lb. per set of three drills in 34 shifts, or say, 17½ lb. per set for 312 shifts.

(II.) *East Rand Proprietary Mines, Limited.—First Experiment*:—

The drilling and sharpening losses per set of four drills (hand sharpened) were observed to be 1·56 lb. in 24 working shifts, equal to 20·28 lb. per 312 shifts.

The loss through "mushrooming" was 2·04 lb per set of four drills in 24 working shifts, equal to 26·52 lb. per set per 312 shifts.

(III.) *East Rand Proprietary Mines, Ltd.—Second Experiment*:—

The drilling and sharpening losses per set of three drills (Challenge machine sharpening) were observed to be 0·822 lb. in 12 shifts, or 21·372 lb. per set in 312 shifts.

The loss through "mushrooming" was 0·578 lb., in 12 shifts equal to 15 lb. per set per 312 shifts.

The average losses disclosed by the East Rand Proprietary Mines, Limited, experiments give the following approximate figures:

Steel actually used in drilling and lost in sharpening—per boy per annum	20 lb.
Note—In the first experiment hand sharpening was used — in the second, machine. The above figure represents the average.	
Steel lost through crushing or "mushrooming" of shank end —per boy per annum... ...	20 lb.

The discrepancy between these figures and those disclosed by the Ferreira Deep, Limited, experiments points to the desirability of further trials under close and scientific observation. It will be noted, however, that the Ferreira Deep figure of 18 lb. of steel lost through "mushrooming" corresponds very closely with the East Rand figure of 20 lb.

The losses disclosed by these experiments show that whilst the sharpening and drilling losses on the bit end, both with the old and new types of drill are practically constant, the experimental sets of jumpers with the new form of drill head disclosed practically no loss through "mushrooming." In the first experiment at the East Rand, it is true a loss of 1·1 in. per set of drills was disclosed, but this was due to the flattening of the crowns. In the second experiment, the same drills being used, the loss per set of three drills in 12 shifts was 0·12 in.

It should be mentioned that the equality of losses disclosed by the East Rand experiments was not borne out by observations some years ago when experiments in comparative losses led to the conclusion that the losses through "mushrooming" were double those caused by drilling and sharpening.

Apart from the other advantages of the new drill previously referred to the saving of steel by prevention of "mushrooming" only may be expressed as follows:—

Inches of steel per native per annum (312 shifts)	103 in.
Pounds of steel per native per annum calculated at 3·11 oz. per in.	20 lb.
Value of steel per native per annum at 4½d. per lb.	7s. 6d.

Assuming an average of 45,000 natives drilling (the five years' average is 45,684), it will be seen that the saving is estimated to be 386,250 ft. of steel per annum, equal to, say, 73 miles, or 450 short tons, valued at 4½d. per lb., and representing £16,875 sterling. The application of these figures to those given in the opening paragraph leads to somewhat startling comparisons between the weight and value of steel issued and the amount which is consumed *bona fide* in the processes of drilling and sharpening (*vide* Annexure "C.")

The deductions to be drawn from these figures are as follows:—

(1) In five years the Rand Companies have issued 9,757 tons of drill steel, valued at £310,250.

(2) Of this about 2,284 tons, valued at £75,655, have been used in drilling or have been lost in sharpening, in addition to which a further 2,284 tons, valued at £75,655 have been crushed up owing to there having been no means to prevent it.

(3) The balance, viz., 5,189 tons, valued at £158,940, has either been added to mine stocks on hand at the beginning of the period selected, or has been used for other purposes or has been lost.

The New Kleinfontein Company, Limited, has had the whole mine equipped for several months past with the new type of drill. The new drills are apparently standing up well to their work and give no trouble. The natives prefer them to the old form. Different varieties of steel require slightly different tempering. This is a matter of

experiment easily adjusted by shop foremen. The tapered form of the new drill head prevents the natives from striking the drill to loosen it should it stick or fitcher. It has been found that a simple form of extractor is desirable. One or two in each stope are found to be sufficient.

Efficiency.—It may be reasonably argued that if it be possible to save the smashing up of 73 miles of steel per annum, the energy conserved should be reflected in increased drilling inches. On the basis of paying 45,000 natives 0·65d. per inch, an increase of 1 in. per boy per day would mean an increase in the annual wages bill of the Witwatersrand of £38,000, that is to say, the industry is willing to pay that amount for the extra 1 in. Assuming the figure of 39 in. per diem as the average drilling efficiency on the Witwatersrand, an extra 1 in. per diem represents 2½% only increase in efficiency.

From this it follows that the direct saving in steel hitherto broken up in the process of drilling is less in value to the mines than an increase of 1¼%, or ½ in. per shift in efficiency. Assuming 45,000 natives drilling, this small increase would represent work for which at 0·65d. per inch, the mines would be willing to pay £19,000 per annum. This amount naturally does not express the full value to the mines of the extra work done—profit on the extra work would have to be taken into consideration.

Expressed in tonnage, and assuming the average efficiency of the fields to be 0·75 tons per native per shift, or 234 tons per native per 312 shifts, an increase of 1¼% only would be equal to 2·92 tons per native per annum, or 131,400 additional tons per annum for 45,000 natives. The figures, if this efficiency could be increased, are interesting:—

1 in. extra, or 2½% increase would mean 262,800 extra tons per annum.
1½ in. extra, or 3¾% increase would mean 394,200 extra tons per annum.
2 in. extra, or 5% increase would mean 525,600 extra tons per annum.

This is a purely arbitrary calculation, as it can be argued and, indeed, demonstrated that under certain conditions the extra tonnage broken by blasting a hole 42 in. deep compared with that from a hole 39 in. deep would exceed considerably the figure resulting from applying the arithmetical ratio of the respective inches drilled.

It may be argued that even with more efficient means a native will do no better drilling; that he is accustomed to stop when he has drilled a given number of inches. This argument must be accepted with some reserve. A test taken over 7,618 hammer boys working on one day disclosed the fact that whereas the average efficiency was 39·7 in. drilled, 46% of the total number of natives tested had drilled less than the average, whilst a considerable number of experienced natives had drilled considerably more. It will probably be found that with improved means the inefficient natives will drill a little more; the natives accustomed to drill about the average may not do very much more, and those natives who are accustomed to drill well above the average will continue to do so with improving efficiency. A boy who is accustomed to drill 48 in. and upwards usually has some incentive to do as much as he can, such as the paying off of an advance for cattle.

Experiments have been conducted to demonstrate that increased efficiency would be obtained, and, on Annexure "D" details are given of some experiments at the Ferreira Deep, Limited, in which very marked increases in efficiency were demonstrated. At the New Kleinfontein Company also the first effect of the drills seemed to be to increase considerably the efficiency of the hand drilling in the Apex Section, but the Company has so far been unable to satisfy itself as to the accuracy of its observations on this point. Some indication of the results obtained are given in a letter from the New Kleinfontein Company, dated 3rd January, 1919, of which a copy is attached (Annexure "E").

It will be observed that in the East Rand experiments, whereas the first series disclosed a slight increase in efficiency, the second showed a decrease, but it must be admitted that these experiments were conducted over a very short period with a small number of drills only—slight variations in hardness of ground from day to day must be taken into account.

The experiments at the Ferreira Deep were very carefully conducted, and the results were borne out by a further independent preliminary trial at the New Kleinfontein which demonstrated an average increase in efficiency of about 30%. It was as a result of these trials that the New Kleinfontein Company decided to instal the new form of drill throughout its mine.

A further point of interest is referred to by the New Kleinfontein Company, viz., the increased wear on hammers and consequent consumption of hammers induced by the permanent head of the drill. At the Ferreira Deep, Limited, where the new drill heads have been installed for some months past, there has, however, been a reduction in the issues of hammers during the last four months of last year. It is possible that the increased issues of hammers at the New Kleinfontein may be due to other causes. If old hammers have been made up or if faced hammers have been used the increased wear may be accounted for.

The importance to the Witwatersrand of increased drilling efficiency appears to warrant a more extended experiment under accurate observation.

Another direction in which further experiments are worth considering is the adoption of a fluted form of steel. Steel of this type weighs about 12½ less than solid steel and carries the new form of drill head without difficulty. It sludges more easily and the inertia to be overcome by the hammer blows would be 12½ less than the solid form of drill. This should tend to greater drilling efficiency. The present stocks of solid steel could probably be fluted at small expense.

Other experiments might with advantage be directed to investigating the best weight and shape of hammer.

It may be observed that if the new heads, owing to faulty tempering of steel, get out of shape, they can be easily trimmed into shape with an emery wheel, or, if necessary, made up again at small cost.

A further point worthy of mention is the elimination of accidents due to splinters of steel. Injuries to the hands of native drillers from steel splinters or fragments knocked off the drills are of frequent occurrence, in addition to which the loss of an eye often happens. The compensation paid and loss of shifts from these accidents would be found to amount to a considerable sum annually. The new form of drill head will clearly reduce such accidents and losses to a minimum if not eliminate them entirely. The native will no longer have to swathe his hands in bandages to hold the drill in position.

As previously stated, the manufacture of the new form of drill head can be effected in a Leyner press with a simple die and dolly in one heat, and the drills can be made up at the rate of 500 per diem. There is no difficulty in providing suitable dies and dollies for meeting the case of smaller mines where it would be necessary to make up the drills by hand, or (if available) under a steam hammer. The tempering is by ordinary methods, varying slightly with different classes of steel, and is easily demonstrated. The cost of the Leyner press die and dolly is £12 10s.

The conclusions to be derived from these experiments may be summarised briefly as follows:—

1. That the loss of steel hitherto sustained by the mines through mushrooming or crushing can be entirely prevented by the new permanent head.

2. That a simple system of steel control can be introduced which will eliminate the heavy losses of hand drill steel from causes other than fair and proper wear and tear.

3. That the consumption of hand drill steel can then be reduced to the amount of steel actually used in the processes of drilling and sharpening.

4. That accidents and lost shifts hitherto caused by splintering of drills can be practically eliminated by use of the permanent head.

5. That there is evidence of an appreciable improvement in efficiency when using the permanent drill head as the energy hitherto absorbed in the crushing up or mushrooming of the shank is available for drilling.

6. That the importance of the foregoing to the mining industry lies in the fact that the work of a very large body of natives (averaging 45,000 per annum) is beneficially affected.

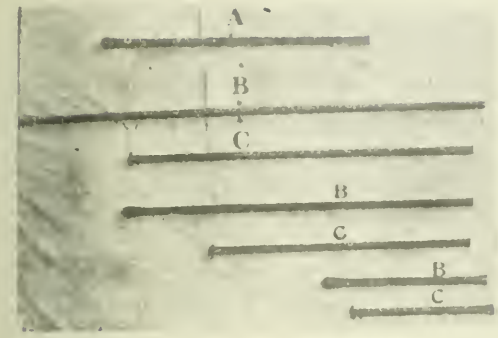
7. That there is a field for further investigation on the following points:—

(a) The relative losses of steel in different methods of sharpening and determination of which is the best method.

(b) The possibility of further improving efficiency by fluting the existing stocks of drills and incidentally the maximum amount of fluting economically possible.

(c) The correct weight and shape of hammer for use in hand drilling.

Hereunder will be found two illustrations showing the permanent heads for native hand-drills:—

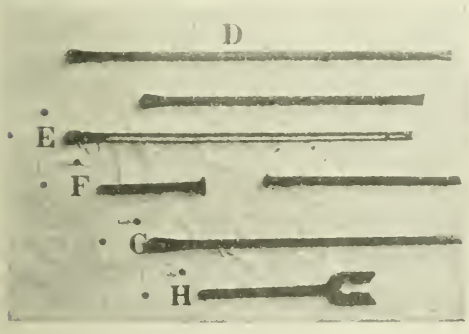


A.—New type of hand drill made at the Ferreira Deep, Limited, used on alternate working days for about eight months.

B.—Set of three drills of new type used at the East Rand Proprietary Mines, Limited, for 36 shifts.

C.—Set of three control drills of the usual type, used at the East Rand Proprietary Mines, Limited, for 36 shifts.

NOTE.—The wear on the ordinary drills compared with the new will be noted by comparing the long, middle and starter drills of each set. All the drills of this set were originally approximately the same length as those shown in set B. The loss of steel through crushing or "mushrooming" of the shank end (set C) in these experiments was at the rate of approximately 20 lbs. of steel per native per annum (312 shifts). In set B the loss was practically nil.



D.—Two specimens of the new type of drill after considerable use at the East Rand Proprietary Mines, Limited.

E.—New type of drill of fluted steel in constant use at the Ferreira Deep, Limited, for approximately eight months.

F.—Two specimens of the usual type of drill showing "mushrooming" of shank.

G.—New type of drill from Ferreira Deep, Limited, showing slightly increased crown.

H.—Extractor.

I have referred previously to a system of steel control, and as it is cognate to my subject, I am able, thanks to the courtesy of Mr. Paul Selby, of the Ferreira Deep, Limited, to give a brief description of the system in use on that mine.

At convenient levels rough cabins are constructed of split leggings consisting of two compartments, one for blunt steel, the other for sharp steel. A passage having a stout door at either end passes in front of and provides access to either compartment. Each door is provided with padlocks. Each cabin is in charge of two police boys, one on duty from 5 a.m. to 12 noon, the other from 12 noon to 8 p.m. The police boys are provided with punches of a different type for each cabin. With these punches the natives' tickets are punched, as the native receives or returns his steel, thus enabling the mine authorities to see at which cabin the native gets his steel and to which cabin he returns it. The natives are allowed to take and deliver their steel at whichever cabin best suits them. Each punch is provided with a small box into which the punched portion of the ticket falls. Each punch portion represents a set of three drills. The punched portions are counted at the end of each morning shift, so that the number of drills taken from each cabin can be replaced that afternoon or evening.

The police boy on morning shift spends his time, after delivery to the drilling gangs is completed, in going round the mine collecting any steel he may be able to find. The police boy on afternoon shift completes his work by packing in the trailers for transfer to the surface the blunt steel collected that afternoon, placing in the cabin the sharpened steel sent down that afternoon to replace the quantity issued that morning.

Every Friday the number of drills left in each cabin after the morning issue is counted and added to the number issued plus the number sent to the surface the previous day. In this way a check is obtained on the steel lost and in circulation every week.

The police boys in charge of the cabins are under the control of the compound manager, and are responsible for giving him timely warning if the quantity of steel is getting short, or if the steel itself is getting short in lengths. The only other official who has any control over the police boys in question is the underground native superintendent.

The compound manager possesses a master punch, and any boy going on hammers for the first time gets his previous day's ticket punched with this, which enables him to obtain his first set of steel.

The effectiveness of this method of control may be gauged when it can be stated that no new steel has been issued from the mine store since its introduction.

My acknowledgments are due to Mr. Paul Selby, manager of the Ferreira Deep, Limited, and to Mr. A. H. Krynauw, of the East Rand Proprietary Mines, Limited, for their courtesy in facilitating experiments.

Annexure "A."

Notes on Experiments at Ferreira Deep, Limited.

The total loss on six starters, five middle drills and seven long drills in 34 shifts (ascertained by measuring from the punch mark to the bit end of the drill) was found to be 22¾ in. The loss, therefore, in 312 shifts would have been 208¾ in.

Taking the average weight of steel at 3·11 oz. per inch of steel, the total weight lost for 18 drills in 312 shifts was, therefore, 40·6 lb., and the loss per set of three drills approximately 6·75 lb.

The losses at the shank end, due to crushing or "mushrooming" were ascertained in respect of six starters, five middle drills and seven long drills, and were found to be 59 1/5 in. in 34 shifts, equal to a loss of 543¼ in., in 312 shifts, or at 3·11 oz. per inch 105·6 lb. of steel. The loss in respect of three drills may, therefore, be calculated as 17·6 lb. per 312 shifts.

The experiments with the new type of drills prove them to be satisfactory, and a considerable number of drills have since been installed in the mine in preference to the old type.

Annexure "B."

Notes on the Economies in Hand Drill Steel.

Results of experiments at the East Rand Proprietary Mines, Limited.

Item	Shifts Worked	No. of Sets Used	Drills per Set	Average Weight per Set (lbs.)	Average Loss after 24 Shifts per Set (lbs.)	Original Average Length per Set from Head to Punch Mark (Inches)	Average Loss per Set after 24 Shifts due to Mushrooming (Inches)	Original Length per Set from Punch Mark to Bit (Inches)	Average Loss per Set after 24 Shifts due to Drilling and Sharpening (Inches)	Average Inches Drilled (5 hours basis)	Sharpening
Experiment No. 1: E.R.P.M.											
Experimental Set ...	24	22	4	28·5	2·1	94·4	1·1	60·1	7·2	36·24	By Hand
Control Set ...	24	22	4	26·7	3·6	89·5	9·5	59·6	7·2	36·04	
Experiment No. 2: E.R.P.M.											
Experimental Set ...	12	20	3	22·6	0·75	88·3	0·12	35·1	4·2	35·4	Challenge Machine
Control Set ...	12	18	3	18·8	1·4	72·0	3·16	29·5	4·5	37·2	

Notes on the Economies in Hand Drill Steel.

Statement showing Theoretical Consumption of Hand Drill Steel, Losses, etc.

Year.	Average No. of Natives Working.	Theoretical consumption at 20 lbs. per Native per annum.	Value.	G.M.E.'s Report, Issues of Steel.	Total Value.	*Difference:* Discarded, crushed, used for other purposes, added to drills in current use at end of 1912 or lost.	Value of difference.	*Deduct:* Weight of steel hitherto lost through crushing, 20 lbs. per native per annum.	Value.	*Balance:* Used for other purposes or added to drills in current use at end of 1912 or lost.	Value.
		£		lbs.	£	lbs.	£	lbs.	£	lbs.	£
1913	43,932	878,640	11,846	1,452,150	60,027	3,573,510	48,186	878,610	11,817	2,691,870	36,333
1914	38,570	771,400	10,312	3,991,061	53,350	3,219,661	43,038	771,400	10,312	2,448,261	32,726
1915	49,110	982,800	14,021	4,538,376	64,767	3,555,876	50,742	982,800	14,021	2,573,076	36,717
1916	51,911	1,098,820	20,700	4,018,329	75,697	2,919,503	54,997	1,098,820	20,700	1,820,683	34,297
1917	41,836	836,720	18,773	2,511,158	56,409	1,677,438	37,636	836,720	18,773	840,718	18,863
Totals and Averages	15,681	1,568,380	75,655	19,514,368	310,250	11,915,988	234,343	1,568,380	75,657	10,377,608	158,936

Annexure D.

Notes on Some Experiments Conducted at the Ferreira Deep, Limited, with Hand Drills.

"(1) All drills (starters, middle and long) were hand sharpened and accurately gauged.

(2) Collaring was effected by 200 blows on each type of starter drill.

(3) The drills of ordinary and new type were then used alternately in the *same* hole, the blows being counted. 400 blows were alternately struck on each type of drill."

Nature of Hole.	Ordinary type Drill.		New type Drill.		Increase in Efficiency, per cent.
	Blows.	Progress, Inches.	Blows.	Progress, Inches.	
Bottom ...	3,600	24½	3,600	25½	5·15
Top ...	3,600	10¼	3,600	13¾	23·2
Top ...	3,600	20¾	3,600	23¾	14·3
Middle ...	2,000	10¾	2,000	12⅜	23·1
Top ...	3,600	18½	3,600	21¾	17·5

Annexure "E."

Extracts from letter from the New Kleinfontein Co., Ltd., dated 3rd January, 1919:—

" . . . . A careful comparative test of the head was made in order to ascertain whether the saving in steel and/or improvement in efficiency which you claim for your invention were likely to be realised.

Increase in Efficiency.—The test which was very carefully carried out showed that there was likely to be an increase in efficiency of about 30 .

Decrease in Consumption of Drill Steel.—This test showed that whilst the loss through crushing or "mushrooming" of drills without the "Read" pattern of head was equal to 6·3 16ths in. of steel on nine drills receiving a total of 36,000 blows, that on a same number of drills with the "Read" pattern head, receiving the same number of blows, was 2¼ in., representing approximately ¼ in. per drill, and apparently caused by a slight flattening of the rounded head, together with a certain amount of compression due to the upsetting of the drill, as there was no appreciable wear beyond this slight flattening of the head and an inconsiderable loss due to scaling. Since the introduction of the "Read" pattern drill head throughout the mine, it has been found that these heads stand up well to the work, and with the exception of very slight flaking or scaling there is no

approximate loss of steel at this end of the drill. No trouble whatever has been experienced with the natives using this form of drill, as a fact they like it very much.

Difficulties have, however, arisen with regard to the tempering of the head end in relation to the hardness of the hammer used and the saving in drill steel is in a measure counteracted by an increased consumption of hammers. It is clearly necessary, therefore, that the temper of the hammer used with the new style of drill must receive consideration.

In order to arrive at some approximation of the saving in quantity of steel used, the following comparison can be made.

The consumption of hand drill steel for the six months ending May, 1918, was 97,015 lb. The quantity of ore during this period, which was mined by hand drills, was 344,126 tons, or a consumption equal to 0·282 lb. of steel per ton.

For the three months ending November, 1918, during which time only the "Read" drill has been used the consumption of steel was 22,277 lb., and the tonnage mined by hand drills 159,700 tons, showing a consumption of 0·139 lb. per ton.

Thus we have—

	Pounds per ton Mined.
Consumption by old form of drill...	0·282
Consumption by "Read" form of drill	0·139
Difference equal to	50·7%

in favour of the "Read" form of drill.

The issue of hammers for the periods mentioned above were as follows:—

	Pounds per ton Mined.
Six months ending May, 1918 3,840 lb.	0·0112
Three months ending November 1918, 5,769 lb.	0·0361
Difference equal to ...	68·9%

in favour of the old form of drill.

This, however, is subject to the above remarks regarding the necessity for varying the temper of the hammers. These figures are arrived at by means of the actual issues during the periods shown, and owing to the shortness of these periods they must be accepted as only approximate.

With regard to the increase in efficiency, if any, many factors have confused the issue and we find our results inconclusive. This portion of the test is surrounded with great difficulty, the increased efficiency might possibly be vitiated by the fact that the native having satisfied himself as to the number of inches he wishes to drill will by means of this increased efficiency be able to do his task in less time.

Again, with the raw native who has progressed with the old drill to, say, 20 in. and with a 30% increased efficiency due to the "Read" drill might be able with the same effort to drill 26 in., but it will be extremely difficult to assess how much of this is due to the increased efficiency of the "Read" head, and how much may be due to the increased efficiency of the native as he becomes more accustomed to his work. Though theoretically it can be shown that his efficiency must be increased, it will be always exceedingly difficult if not impossible for the reasons above stated to place a value on it.

It would appear that once the heads are properly made and tempered they should last the life of the drill and short ends can be welded on to fresh steel."

The President: Mr. Read is a newly elected member of this Society, and you will admit that he has certainly established his claim to membership in a most effective fashion. The subject that he has introduced this evening is one that is, of course, of much interest to mining men. It has been dabbled in in a more or less effective fashion for a number of year, but I do not know whether the whole position has been so clearly set out as Mr. Read has done this evening. I have had the opportunity of following up his line of research. His conclusions are perfectly obvious, and if afterwards those of you who are interested—as I am sure you all are—will ask him to show you the exhibits he has brought here, it will be proved to you very much more clearly than by any figures the experiments on which his argument is based. You will then have no hesitation in giving the matter very serious consideration.

There is one point that the critic can take up, and that is, if the whole of the energy applied is utilized in drilling and there is no wear on the drill head, can it be presumed that there is no wear on the hammer head. Whether this is the case or not, Mr. Read no doubt at some future period will explain. At the same time, I think if there is a corresponding wear on the hammer that is a matter which can be remedied

in the same way as he has remedied the wear on the shank. With these remarks, I beg to propose a hearty vote of thanks to Mr. Read for his most interesting paper.

Gentlemen, I have been very remiss in not welcoming back our late President, Mr. Hildick Smith, and, in doing so now, I shall be very glad if he will be good enough to make a few remarks in seconding the vote of thanks.

Mr. G. Hildick-Smith (*Past-President*): I thank Mr. Meyer very much for welcoming me back on behalf of the Society. The work I have been doing while in England I will write some notes on for the Society at some future time, which will perhaps be of interest to some members, especially those interested in farming.

With regard to remarks on Mr. Read's interesting paper, unfortunately I have not had a copy of the paper to follow as it was read, and I therefore do not feel prepared to discuss the paper in detail as I hope to do at a future meeting. There are, however, several points in it on which I would like to comment. It is an interesting piece of research work, a class of work that is not done sufficiently often on the mines, as no organised systematic research work is yet being done. This kind of work is only done in a haphazard manner or as a matter of curiosity, as Mr. Read remarked to-night. It should not be done out of curiosity, but as part of the organised work of any one Group or of the Industry as a whole, and the sooner any one group or the Industry organise on such lines as to permit of systematic research work, the sooner will the mines show a continuously increasing efficiency.

The President: Well, gentlemen, there are apparently no further remarks on this subject to-night. I must again strongly advise you to examine these exhibits which Mr. Read has been kind enough to bring here, and I have no doubt that at a subsequent meeting many of you will have contributions to make to the discussion.

Mr. D. R. Robinson (*Associate*): Might I ask the name of the inventor of this head?

The President: The inventor is Mr. H. V. Read, who read the paper.

CEMENTATION PROCESS APPLIED TO MINING (FRANCOIS SYSTEM).

By A. H. Krynauw (Member).

(*Printed in Journal, May, 1919.*)

The Secretary: Mr. Krynauw asks me to apologise for his absence to-night, and to say that any reply that he could have given was most ably given by Mr. Blandford at the last meeting.

THE ESTIMATION OF OXYGEN IN WORKING CYANIDE SOLUTIONS.

By H. A. White (Vice-President).

(*Printed in Journal, June, 1918.*)

REPLY TO DISCUSSION.

Mr. H. A. White: I have to thank those members who took part in this discussion, and particularly Mr. Wattenweiler and Mr. King for the interesting records published.

It appears that on certain plants some of the solutions persist in giving a purple or violet coloration, which does not, as in my own experience, rapidly change to the usual brown. I have made a number of experiments on synthetic solutions with the object of tracing the cause of this peculiarity, and now believe it to be caused by complex ferrous or ferric salts, such as are formed with tartaric acid, and many other organic compounds containing the (HO) group such as hydroxy-acids and sugars. Such compounds in dilute alkaline solution are not precipitated by alkalies, cyanides, ferrocyanides, ferricyanides or sulphocyanides, and in very dilute solution are only coloured light green by alkaline sulphides. A simple experiment with ferrous or ferric sulphate dissolved with considerable excess of Potassium-sodium tartrate (Rochelle salt) will demonstrate the above facts, and will also show the peculiar violet to purple shades with pyro (or pyrocatechin or Gallic acid) in very weak cyanide solutions. Strengthening the solution with pure sulphide free cyanide might improve the test, but it would surely be better to try to remove the cause, which cannot be conducive to good extractions. This cause is most likely to be associated with the use of mine water in the reduction plant. This usually contains ferroso-ferric sulphate and organic matter, and should be rendered

alkaline and then oxidized, either by good air treatment (exposure in dams or other good aeration) or by the use of permanganate or bleaching powder, as has been done in some cases for years past.

With reference to the removal of oxygen from solutions in order to lessen the consumption of zinc, to improve precipitation, and to eliminate white precipitate, I have found that this is possible by chemical means, as the following experiment will show:—

Add to $2\frac{1}{2}$ litre bottle full of solution (entering slime boxes) 0·28 gm. of $MnSO_4$ as concentrated solution. Shake well and leave, carefully stoppered, to settle for 18 hours.

Solution before treatment: KCN 0·012 %, O 6·5 mgm. per litre.

After treatment: KCN 0·011 %, O 1·0 mgm. per litre.

The white precipitate of manganous hydrate turns quickly to the brown colour of the hydrated dioxide, but the reaction is not quite complete, as only 0·226 gm. of manganese sulphate is called for to correspond with the oxygen removed according to the equation:—

$$MnSO_4 + O + 2\ NaHO = Na_2SO_4 + MnO_2 + H_2O$$

Even if a regenerative process were used it would not be possible to bring down the cost much below 0·4d. per ton of solution, whereas at pre-war prices the advantage to be gained from saving in zinc and acid would be somewhere about 0·3d. per ton of solution, apart from any cyanide lost in white precipitate or gain of gold from better precipitation. It would be therefore better to use a mechanical method such as spraying into a vacuum, for this as well as for the kindred object of removing air from boiler feed water, where the gain would be lessened corrosion and possibly better vacuum in condensing plant. In this latter case it may be pointed out that condensed water contains very little oxygen, and should be returned to the boilers with as little agitation and air exposure as possible. Mere exposure to a vacuum without agitation is little use, as the following figures testify.

	m.p.l.
Solution entering slime at 25° C. oxygen	6·5
After 30 min. exposed to $22\frac{1}{2}$ in. vacuum	5·0
After 60 min. exposed to $22\frac{1}{2}$ in. vacuum	3·5
After 19 hours exposed to $22\frac{1}{2}$ in. vacuum	Nil.

Some experiments I have made indicate that the diffusion constant for oxygen is about 1 cm. per day, and this explains the above results, and also shows why the oxygen replacement in solutions is rapid only where there is considerable movement or convection is possible. If the temperature in a sump were kept uniform it would be years before the bottom layers got saturated with oxygen, as diffusion varies as square of time.

The fact that zinc is slightly soluble in cyanide solutions, even in the absence of oxygen, is best illustrated by the following experiment, which, however, also shows the saving to be made by its removal:—

Some commercial zinc sheet was rolled out very thin and 10 pieces of the same size were cut out to expose 7·5 sq. cm. of surface each. One piece was hung up in the inflow, one in each of the eight compartments of an extractor box, and one in the outflow, all about 1 in. below the surface. The alkalinity and cyanide strengths were very much alike both top and bottom of box at 0·011 KCN and 0·016 NaHO and the temperature about 25° C.

Place.	Oxygen. Mgm. per litre.	Zinc Loss. Mgm. per sq. cm. per 24 hours.	REMARKS.
Inflow ...	6·5	2·33	Heavy irregular gold.
Cpt. 1 (No Zn.)	6·5	1·80	Even coating of gold.
,, 2 ...	3·0	0·73	Heavy irregular gold.
,, 3 ..	0·5	0·53	,, ,, ,,
,, 4 ...	Tr.	0·50	,, ,, ,,
,, 5 ...	Tr.	0·09	,, ,, ,,
,, 6 ...	Tr.	0·07	Light uneven gold spots.
,, 7 ...	Tr.	0·06	Traces gold in specks.
,, 8 (No Zn.)	0·5	0·13	,, ,, ,,
Outflow ...	1·0	0·43	,, ,, ,,

The exposure was for 24 hours, and each piece was washed in ammonia to free it from zinc hydrate, but no allowance was made for gold deposited when weighing up. The influence of the gold deposited in creating a "couple" is shown by the fact that plain cyanide solution of this strength will only dissolve about 0·18 mgm. of zinc per sq. cm. per 24 hours when nearly free from oxygen and not more than 0·8 mgm. when saturated with oxygen, though gold is dissolved at six times that rate.

THE EFFECTS OF DUST INHALATION

By J. S. Haldane, M.D., F.R.S
(Hon. Member).

(Printed in Journal, July, 1918.)

DISCUSSION.

Dr. L. G. Irvine *(Member).* I do not think that I have anything to add to the discussion on Dr. Haldane's paper which has not already been said by someone else. But there are one or two points suggested by the paper and the subsequent discussion upon it which I may perhaps refer to even at the cost of repetition.

We in this Society have always been assured of Dr. Haldane's ready sympathy and co-operation in our attempts to solve our particular problems of mining hygiene, and I need not remind members of his numerous important contributions in the past to the columns of our *Journal*. I consider it a very high compliment that Dr. Haldane presented the paper under discussion to this Society simultaneously with its presentation to the Institution of Mining Engineers in England.

The paper is marked by the lucidity and suggestiveness of all Dr. Haldane's work, but the author does not claim finality for his conclusions. The paper contains several valuable new ideas which are put forward for confirmation by further experiment and research. Dr. Haldane emphasises the fact that the intervention of the war has necessitated an interruption of the experimental investigation on which the paper is mainly based and that investigation requires to be confirmed and amplified.

The puzzling difficulty of which Dr. Haldane offers an explanation is this: Why is it that although the dangerous element in those mineral dusts, prolonged inhalation of which produces fibrosis of the lungs and an excess mortality from tuberculous phthisis, is quartz or crystalline silica, nevertheless other dusts which contain a considerable proportion of quartz, such as coal-mine dust or shale dust, are relatively harmless, and cause on prolonged inhalation no such excess mortality.

As the result of a series of experiments on animals, Dr. Haldane offers the explanation that while all dusts are *taken up* into the lungs by "dust cells," the relatively harmless dusts are composed wholly or partly of substances which stimulate the "dust cells" and the lungs to *remove* not only the harmless dust particles themselves, but the potentially harmful alien particles as well.

In one crucial experiment—unfortunately circumstances appear to have permitted only one—flint dust mixed with coal dust was used for inhalation, and "the results indicated that practically the whole of the flint dust was removed in a moderate time."

Dr. Haldane is therefore led to make this practical suggestion: "If we cannot altogether prevent the inhalation of dangerous stone dust we can apparently neutralize its effects by causing another kind of dust to be inhaled with it." He suggests as a "neutralizing" dust say 60% shale with coal dust.

Now we must, I think, admit that that is the position on the Rand to-day. In spite of all that has been done underground, the inhalation of fine siliceous dust has not been entirely prevented, and cases of silicosis continue to be produced, although I certainly believe in much smaller numbers than previously. The result in actual practical operation of the methods introduced under Government regulation on the Rand, namely, water jets, water blasts, general watering, better ventilation, the prohibition of blasting the cut and round on the same shift, and finally the prohibition, except by special exemption, of blasting more than once in twenty-four hours, has been that the amount of dust in mine air has been enormously reduced, but the extremely fine injurious dust has not been removed to the point that silicosis is no longer produced. These methods are all good, and the last named comes by no means last in importance. But the position, nevertheless, is that although we have scotched the snake, we have not yet killed it. And that being so we must welcome any practical suggestion which may enable us to add to our preventive measures against miners' phthisis. It is necessary therefore that the practical efficacy of Dr. Haldane's suggestion should be thoroughly tested on every side. But even if it should be found to fulfil all that it promises, it must be regarded as supplementary, and not as an alternative to the dust-laying measures already introduced.

But the discussion has shewn that we are still far from fully understanding the problem.

Dr Haldane suggests that the dangerous qualities of quartz dust are not due merely to the fineness and sharpness of its particles. He suggests that if that were so the crystalline quartz in shale dust should also produce injurious effects. But one thing we have established on the Rand is that, not the only, but the *main* danger from dust underground comes from *blasting* dust, and that the particles of blasting dust are excessively fine and minute. Now, has any strict comparison been made of the size and character of the particles of quartz in shale dust with our blasting dust, or is there any proof that even although shale dust may contain 30 or 50 of quartz in bulk, that that proportion enters the lungs or that it enters in a condition at all resembling blasting dust? This criticism has been made by others, and it appears to me to be a cogent one.

Again, although it is true that the inhalation of coal mine dust does not produce an excess mortality from tuberculous phthisis, it is not true that it does not produce fibrosis. One should not in this relation speak of "coal dust" unless one means *pure* coal dust, but of "coal mine dust" or "colliery dust," since it has been shown that the dust found on the roads and other surfaces in coal mines contains a considerable proportion of stone dust. In the possession of the Miners' Phthisis Medical Bureau, as Dr. Watkins Pitchford has told you, there are several plates showing very definite fibrosis in the lungs of men who have worked underground only in coal mines over long periods. One plate in particular shows a well marked change identical in appearance with an early silicosis. Probably it is the quartz in coal mine dust which is responsible for this result. I have very little doubt that if the same intensive radiographic examination of coal miners were made as is made of gold miners here, we should find quite a fair number showing definite signs of fibrosis. No doubt the fibrosis may develop less frequently and more slowly and to a less degree. But the cardinal difference between the gold miner and the coal miner lies, as stated by Dr. Watkins Pitchford, in the fact that in the former the fibrosis of the lung is associated with an excess mortality from tuberculous phthisis, while in the latter not only is there no excess mortality from tuberculosis, but the mortality from this cause is lower than that of occupied males in general. Dr. Haldane's suggestion that the inhalation of coal dust stimulates the removal of tubercle bacilli as well as dust particles from the lungs is here most illuminating.

Further, the discusion makes it clear that the physical and chemical properties of the non-injurious "neutralizing" ingredients of the relatively safe mineral dusts are not yet thoroughly understood. Dr. Smeeth points out, for example, that Kolar mine dust contains as much quartz as granite, and as much crystalline silicate in addition, yet the former is apparently not injurious, while granite is responsible for the silicosis in Cornish tin mines (so far as that is not due to imported cases from the Transvaal).

It is plain that these and other similar points must be cleared up by further investigation before we can really understand the question fully. Dr. Haldane has restated clearly and in a new light a problem which was before a puzzle, and he has indicated equally clearly the way in which it may be finally solved by further investigation. The experiments under his direction will no doubt be continued and final results reached. But several contributors to the local discussion have urged that we should do our own experimenting also, and that so far as its application to the miners' phthisis problem on the Rand is concerned this investigation should be continued here in South Africa.

An immense amount of valuable work has already been done here, especially by the Miners' Phthisis Prevention Committee and by others in elucidating the practical side of dust measurement and dust prevention. A very large share of the credit for this is due to Sir Robert Kotzé and to the co-operation in the work of the Chamber of Mines. Mr. Innes's recent paper is an excellent example of this side of the work. And I think we may claim also that in the elucidation of the clinical aspects, the pathology and the radiography of silicosis and tuberculo-silicosis we are far ahead of any other country. So that I am glad to be able to say, on the authority of Dr. Watkins Pitchford, that arrangements are already in train to have this new aspect of the question raised by Dr. Haldane thoroughly investigated locally at the South African Institute for Medical Research. The experimental work on silicosis in rats planned by Dr. A. H. Watt, the results of which were communicated to you recently by Dr. Pratt

Johnson, have shown the value of experiments in situ. Strict laboratory experiments are also necessary. All of this preliminary work is essential before any practical steps can be taken in the way of an extensive application of Dr. Haldane's suggestion. Whatever the result of this investigation may be, we must always remember that the main enemy is blasting dust, and personally I doubt very much whether the shale and coal dusting of wet roads and faces will prevent the rapid dissemination in the air of the fine dust produced at blasting. I should still rely more on single shot blasting and getting as many men as possible out of the mine before blasting time.

The alternative suggestion has been made of passing all miners through a coal dust chamber or area for certain periods of the day. This might be feasible and valuable if its obvious difficulties in loss of working time and the inevitable objection of human inertia and other conditions could be met. It would appear from the results of Dr. Haldane's observations that to secure the removal of siliceous dust from the lungs the inhalation of the dangerous and the neutralizing dust should, as far as possible, go on *simultaneously*. Once the particles of silica are encapsulated by fibrous tissue their removal is not likely to occur to any great extent, although it is known that a certain amount of elimination does occur. Hence the interchange of miners between coal and gold mines seems a feasible suggestion from the medical standpoint, whatever it may be from the economic side. On the other hand to send miners already affected by silicosis to coal mines in the hope of an amelioration of their condition is not likely to do much, if any, good except perhaps in early cases. These, however, are points the value of which only time and experience can prove. I regret that what I have said has been, as I stated at the outset, mainly a repetition of what has been said by others, but as I have been absent from Johannesburg for some time and the question has meanwhile been very thoroughly discussed in England or locally, this was inevitable.

The President: I understand that Dr. Macaulay also has a contribution on this highly important subject, but it will be published in the *Journal*.

I should just like to remark that I am sure that all the members of this Society feel highly gratified to know that this matter is not to be allowed to rest, and that a really practical although it is going to be possible to follow up the lines of Dr. Haldane's conclusions.

I must also add that I can give the assurance that members of the Society who may be at the highest practical use in carrying out these experiments will get every the fullest cooperation.

THE APPLICATION OF THE THEORY OF PROBABILITY IN THE DETERMINATION OF ORE RESERVES

By G. A. Waterman (Member of Council).

Printed in Journal, January, 1919.

DISCUSSION.

Mr. H. A. White (*Vice-President*): Of the "Law of Error" of which the author has given us an able and convenient abstract, it has been remarked by H. Poincaré, "everybody firmly believes in it because mathematicians imagine that it is a fact of observation, and observers that it is a theorem of mathematics." It has however, been found by the author to give a rough representation of distribution of gold values though what is called the "fit" of his curves to his observations is distinctly bad. It may be remarked in passing that the "skewness" of the "best" curve for any mine is probably closely connected with the percentage of payability of the ore reserves which, of course, determines the proportion of low valued samples which are excluded. Nevertheless, these curves are of very great interest, and justify the labour which has been expended in their preparation.

It is an axiom that nothing more can be got from the mathematical mill than has been put into it, the result being a change of form rather than of substance, and if any process whatever be devised to reduce the ascertained value of ore reserves or value of ore stoped, the assumption that ordinary sampling tends to give high results must be slipped in somewhere. Wherever, therefore, this is the experience an average factor which directly emphasizes that experience should be used as this involves no other assumptions whatever, will save a lot of calculation and a lot of elaborate mathematics—sometimes not justified by the "coarseness" of the observations, and occasionally, as in this instance, without logical justification.

The author's logical lapse occurs where he quotes the astronomer's determinations from his observations of the weight he may attach to them, and says *in a similar way* we may determine from the frequency of the occurrence of different values the relative weights we may attach to them when they occur in stopes.

The astronomer makes many different determinations of a single fact, and his small differences are due to just such causes as the law of error is calculated to provide for, so that his final result gives the most probable value when so corrected. In order to make the author's "similar way" logically justified, one large sample of rock must be carefully powdered and well mixed and a large number of assays must be made from properly selected small portions thereof; analysis of the results might then be made by the "law of error" or the "method of least squares," but even then the mere arithmetical mean would be of sufficient accuracy.

This, however, is a very different thing from the method adopted by the author to determine the average value of many samples of different things only loosely connected. If the frequency curve obtained were symmetrical no great harm would be done, but in the more usual skew curve the error is considerable and amounts to a reduction of 30 of average value in the numerical illustration given. The method adopted when stripped of its mathematical garb amounts to this:—It is a fact that high values are not so frequently found as those nearer the pay limit, and we are not content to allow for this fact once, as in the ordinary average, but think it should be allowed for once more by weighting in accordance with scarcity.

There is as yet no reason to suppose that the distribution of gold in the reefs worked is arranged in such a fashion, with reference to development lines, that the ordinary samples must give incorrect results, and there is no theoretical justification for the usual assumption that a value over 2,500 inch-dwt. must refer to a smaller quantity of rock than one of 400 inch-dwt. If sufficient numbers of samples are taken the number of high-valued results must closely correspond with the quantity of ore of that value, if as is usual the exposed reef is commensurate with the tonnage developed. If such ore is very rare such samples must be equally rare, and the usual average is correspondingly affected.

Having demolished the mathematical shelter from the fire of criticism upon differences between mill value and stope assays, it is necessary to point out the real causes of the difference frequently found.

Sampling.—This is generally done with very great care, but frequently too many samples are required for the day's work. However conscientiously done the tendency must be to produce too high results for the following reasons. The real width of the reef exposed can only be found if the exposed face includes the shortest line and the measurement is made in the correct direction:—*Any "error" must be in excess* Measurement of stope widths is difficult especially when "choked" with broken rock, and is usually reckoned too small, as is proved by comparison of stope and mill tonnages.—*This also makes stope values too high.* Frequently the richer portion of the reef is most friable, and often the lower portion of the reef is richer than the upper portion; although samplers are well aware of these facts, there is in consequence a well marked tendency for the sample to be higher than the face it is taken from. Notwithstanding these facts, sampling is usually so well carried out that the whole discrepancy can hardly be accounted for in this way.

Mining.—Not all the gold in the rock mined is sent to the surface. In the first place, blasting scatters a certain amount of fine but rich dust, portion of which is lost. Underground sorting for waste packs involves a certain loss of gold, which may sometimes be considerable. The uneven stope floors catch a quantity of gold, of which only part can be recovered by sweeping, which is often not carried out thoroughly and frequently.

Of the gold hauled to the surface, some is sent to the waste dump in sorted rock, which it is not possible to accurately sample in the usual manner attempted, and although the gold stolen is no longer estimated at 10% no one imagines that absolutely no gold is lost in reduction operations.

The author's own figures well illustrate the absurdity of trying to balance up the gold month by month with the variable absorption caused by plates, tubes, extractor boxes and by-products, but his practically constant plus results on the Van Ryn G.M. Estate for 1918 certainly throw considerable doubt upon the practical advantage to be

obtained from the labour the new method involves.

In conclusion, I would like to remark that whatever opinion ultimately prevails, with regard to the avowed object of this paper, it must be conceded that a large amount of work has been very profitably expended in producing a novel and valuable picture of gold distribution.

Mr. H. R. Adam (*Member of Council*): Those in the best position to discuss this paper thoroughly are mathematicians, who may dispute the mathematical reasoning, and those in possession of data for or against the premises on which the method is based. There is, however, a great deal of value in the paper to the assayer who is interested in the general scheme of mine work, as well as in his own particular branch.

The first obvious criticism is that Mr. Watermeyer has applied the theory of probability without discussion as to whether it is really applicable. It is open to argument whether this is justifiable even though he obtain better agreement in the examples given. His method is based on the assumption that the discrepancy between mill yield and estimated values is due to the effect abnormally high values have on the arithmetic mean, but he has given no consideration to the possibility that this may not be the main cause of the discrepancy at all. The very fact that the discrepancy is always on the one side indicates that there are sources of constant or biassed errors either underground or in the mill and probably in both places, and before applying the theory it would be necessary to eliminate these as far as possible. A detailed discussion of such possible "constant errors" is of course a matter for the mining expert; it may merely be noticed here that monthly mill returns are liable to considerable error, since the yield can no doubt be modified according to the thoroughness of the "clean-up." The mill returns for a year would be safer figures to go on. As an aside, the method of returning the gold yield as "mill yield—pulp" strikes one as curious. It indicates that the assaying does not control the amalgamation.

Assuming, however, that investigation has shown that the discrepancy is not due to such "constant errors," and that Mr. Watermeyer's view is the correct one, does it necessarily follow that a "skew" frequency curve results? The practice of cutting down the high values by one or other of the methods indicated in the paper apparently supports his assumption, but it must be noted that the cutting down may be done simply to meet the expected discrepancy without admitting that the discrepancy is really due to the high values. The author's argument is that while the £100 note in the church plate may disturb the arithmetic mean, it does not greatly affect the "mode" of the collection. On the other hand, the £100 note makes a big difference to the total yield.

Mr. Watermeyer accepts the asymmetry of the frequency curves and gives us two examples, without discussing possible causes of the "skewness." It is very difficult, however, to understand why the high values should have this effect, provided the sampling and assaying of rich areas is reasonably correct. In a rich block of ore there should be just as much chance of abnormally low values as of abnormally high. One example of a statistical skew frequency curve is given in the paper, viz., the drawing of white and black balls from a number in which the blacks to the whites are as 2 to 1; but it is doubtful if this is strictly analogous, since in the curve given only the percentage of white balls drawn is considered. In any case, it would appear necessary before plotting the frequency polygons to re-sample the areas of high values. If, however, further investigation continued to result in "skewness" of the frequency curves, then the author's method must be considered thoroughly rational. The writer admits to great difficulty in understanding these "skew" curves; two examples are, however, given in the paper, and if substantiated by further evidence it is difficult to see how Mr. Watermeyer's argument can be got over. His argument, in brief, seems to be as follows:—

For some reason or reasons unknown abnormally high values have more than their due effect on the method of estimating ore reserves as based on the arithmetic mean. This is borne out by the "skew" frequency curves, because if these were symmetrical the arithmetic mean would be the most probable mean. It is not necessary to investigate the matter further, because, even though something in the nature of constant errors in sampling or assaying is indicated, a sufficiently approximate correction can be made by a rational system of weighting.

If the above is anything like a correct

statement of the author's argument, it means that he proposes to correct for biassed errors by applying the theory of probability, and we are told in books on the subject that it is most important to eliminate such errors if at all possible.

Whether Mr. Watermeyer's system is feasible in practice is a matter for mine valuators to decide. It may be remarked, however, that the method of obtaining the smooth weighting curve from the frequency polygon is fairly complicated, and that all that would appear necessary or justifiable, considering the many sources of error, is a direct smoothing through the points on the empirical chart. Small errors in weighting would not greatly affect the final result.

Whatever be the final opinion of experts on Mr. Watermeyer's ideas, there can be no doubt as to the value of his paper, since it leads up to an investigation as to whether quite irrational methods of cutting down values need be persisted in.

Mr. L. D. Hingle (*Member*): Mr. Watermeyer states that predictions of mine grade based on the arithmetic mean of sample values are invariably in excess of the mill return, and concludes therefrom that the arithmetic mean of mine sampling results is not the most probable mean. He considers that the discordance between mine sampling and mill return is mainly brought about by attaching equal importance to every sample value recorded. Acting on the assumption that the frequency with which an inch-dwt. value has occurred in a particular mine in the past is a measure of the weight to be attached to that value when met in a current working place, he develops a method of averaging a number of samples on this basis.

The fact that the average value of ore per ton mined as *commonly* calculated from mine sampling is almost invariably in excess of the average value per ton as deduced from milling value, is readily conceded, but the discrepancy is almost entirely due, in my opinion, to causes which have nothing to do with the method of averaging values. These causes may conveniently be divided into two classes, the first dealing with considerations of tonnage, and the second of value.

It is a well-known fact that over a long period the tonnage obtained from the stopes in a mine is invariably in excess of that broken, as calculated from the measured stope width and fathomages, due allowance being made for any reef put into packs or left lying underground. There is always a certain amount of tonnage which cannot be accounted for. Where does this excess tonnage come from, and what is its effect on the average grade as determined by mine sampling?

Among the possible sources to which it can be traced we may mention the following:—

(*a*) The sampler may have erred on the small side in measuring his stope width. This is without doubt a common occurrence, the width being taken too close to the face, or allowance not being made for increased width when cutting through faults.

(*b*) A certain amount of rock may be added to that broken in the stope face by the breaking away of hanging or footwall. This rock will usually be waste or bands of very poor reef, having a gold content much below that with which every ton from the stope is being credited, and there is grave danger of much of this low grade rock or waste being sent out of the stope labelled with the value of the face sampling.

(*c*) Underestimate of tonnage derived from reclamation and sources other than straight stoping is probably a common occurrence in many mines. In those properties more particularly which have very extensive workings, it is difficult to keep account of every ton of rock derived from reclamation. In the subsequent allotment of tonnage to individual working places a portion, at least, of any such rock of which the surveyor has no knowledge, is credited to current stoping. Any such reclamation tonnage will usually be of lower grade than the ore being derived from stope faces. This will be confirmed by a glance at the average value put on other source tonnage in a large number of mines, apart from any error introduced in the actual sampling of reclamation points as referred to later, and the possibility of the miner appropriating any waste lying around in old workings, which the sampler has not considered in estimating his average gold content.

Gold derived from such operations as the removal of rich footwall leaders which have previously been allowed for in the valuation of a block of ground, but have been left behind accidentally on stoping, cannot be credited to reclamation. This gold must be added to that obtained from stoping in the area in question, otherwise the gold obtained from the block will apparently fall short of

the estimate, even though the latter may have been quite correct.

(*d*) Several smaller factors might give rise to a discrepancy between tons trammed and broken, such as omissions in the surveyor's measured fathomage, or an error in specific gravity in determining the tonnage contained in a given volume of rock *in situ*.

Any overestimate of the tonnage milled on the part of the metallurgical officials will not only increase the discrepancy between tons broken and trammed, but will also reduce the average mill grade per ton to an incorrectly low figure.

Whatever may be the origin of the excess tonnage, there can be no doubt that it is always with us, and the probability is that it is mainly waste or rock of very low grade. Most of it can probably be traced to sources (*a*) and (*b*), when its gold content will be practically nil.

It must be borne in mind that the sampler's dwt. per ton value *based on his measured width*, is the figure on which the average value of the ore mined is calculated. This width is invariably too low. Supposing a sampler takes a number of sections in a stope and arrives at an arithmetic mean for the inch-dwt value of that stope. His average *inch-dwt.* value may be *quite correct*, but his *dwt. per ton value will be too high* if his measured width does not approximate to the calculated width at which the stope has been worked, *i.e.*, the average width which the stope must eventually have reached by some means or other, as determined by the fathomage broken in the stope and the tonnage trammed from it, allowance being made for reef retained in packs and elsewhere.

It is a well established fact that the sampler's measured width in a mine in which tonnage is not being accumulated is invariably lower than the calculated width, which is directly due to the excess tonnage referred to above. A few widths taken over a period of one year (1918) will illustrate this point:

	Measured Width Inches.	Calculated Width Inches.
E.R.P.M.	52·0	61·0
Wit. Deep	61·8	65·0
Knight Central ...	71·6	76·7
Rose Deep ...	71·9	79·2
Geldenhuis Deep ..	60·7	65·0

If the sampler's width is too low, his value per ton must be too high. To get a more nearly correct figure for the number of dwt. we may credit to every ton of rock trammed from a stope over a considerable period such as a year, we should divide the average inch-dwt. value of the stope by its calculated width, always allowing for reef retained in packs. It will then be found that the dwt. per ton value of the ore mined, based on mine samples averaged arithmetically, will agree quite as closely with the mill return as samples averaged on Mr. Watermeyer's system. When considering a whole mine over a long period, the effect of accumulation or withdrawal of rock from individual stopes will usually be small, when the total tonnage mined for the period is considered.

The following figures from a few mines based on a year's work (1918) will illustrate the above remarks. Assuming the mine sampling to call for a value represented by 100, as determined on the basis outlined, the actual value accounted for in the mill has been as follows:—

Geldenhuis Deep	98·7
Knight Central	92·9
Rose Deep	98·9
Wit. Deep	96·1

The effect of cutting down high values by one of the methods referred to in the early part of Mr. Watermeyer's paper is illustrated by making a similar calculation on the year's work of the East Rand Proprietary Mines, on which one such system is in vogue. Taking the mine sampling to call for a value represented by 100, the actual value accounted for in the mill during the year was 105·3. It is obvious that figures such as the latter cannot be used for determining the true state of affairs or for making comparisons between the actual sampling and the mill return. Calculations have been based on a year's operations, since the average mill grade determined on mill yield plus pulp for any particular month may be influenced to a considerable extent by fluctuations in the mill clean-up.

The above figures are taken from mines in which the amount of broken ore accumulated underground during the period under review was small compared with the total tonnage mined. We may reasonably infer that the same conditions of excess tonnage and value exist in a mine which is temporarily accumulating a considerable quantity of broken ore in stopes, with the result that less tonnage is being trammed than broken.

Considerations of value.—Attention may be called to two common sources of error in actual sampling which tend to credit the ore mined with an unduly high value, and which may easily be responsible for a final discrepancy of 2 or 3 :—

(1) It is a common thing for an inexperienced man to salt a sample unconsciously by overstating the width over which the sample is taken, with the result that the inch-dwt. value returned for the section is too high. This error is especially apt to creep in when narrow bands of reef are being sampled.

(2) Tonnage from reclamation is often returned at an unduly high value.

It is sometimes difficult for a sampler to make a close estimate of the amount of exterior waste which will actually be broken with the reef in such operations as footwalling, more especially since the hanging and footwalls are often bad in localities where old workings exist. It is more than likely that the width over which the sampler's dwt. per ton value is estimated is often exceeded in practice, with the result that a certain amount of waste, which he has not allowed for, is trammed out and credited with a gold content which it does not possess.

Any errors in actual sampling, such as these, cannot be determined or allowed for, in contrast with errors introduced by tonnage considerations as outlined above. Their effect will be to cause the mine sampling to call for a higher value per ton than that obtained in the mill, but this will be counterbalanced to a certain extent by any gold which may be contained in the excess tonnage from stopes.

It is probable that in some mines insufficient care is taken that all the fine is swept out of the stopes. The not inconsiderable amount of gold contained in this fine has been put to the credit of the ore taken from the stopes, and if some of this gold is left in the mine we cannot expect to account for it all in the mill.

Mr. Watermeyer uses all the recorded section values in stopes over a period of, say, twelve months, and from the frequency of occurrence of the various values he constructs the table which he uses for weighting individual inch-dwt. values when they appear in stopes. Now, unless the samples taken during the year have been spread uniformly over the rich and poor stopes, his curve of frequency will not represent the most probable weight to be placed on individual values. In practice, it frequently happens that it is not possible to have every stope sampled each month, consequently the rich stopes are commonly left over while those near the pay limit are sampled more frequently. This would result in the lower inch-dwt. values being given an unduly heavy weight in the curve, and all the stope sampling would be discounted to a greater extent than justifiable, even assuming the premises on which the curve is constructed to be correct. In such a case it would appear to be safer to make use of development values only, since they are at least spread uniformly over the mine, and, generally speaking, the most experienced sampler is put on development work.

To get data to which such an exact mathematical treatment could be applied, it would be necessary to have samples taken at predetermined equidistant points all over the reef. This could only be done by dividing up the plane of the reef into, say, 5 ft. or 10 ft. squares, and taking samples at the corners of these squares. Such an undertaking could never be successfully accomplished in any mine.

With regard to the practical application of the frequency table to ore reserve valuation, it seems probable that on a large mine the process will be very laborious. Every single inch-dwt. value around the perimeter of each block will have to be multiplied by its weight separately in the process of meaning. This will be the case if I am correct in assuming that it will be impossible to construct a permanent table for each mine, showing the original inch-dwt. values and the corresponding weighted values, since the weights will have to be revised each year to take into consideration the latest sampling results. With development values at 5 ft. or 10 ft. intervals, the ore reserve calculation will become a much longer operation than on the common method, in which an average value can be put in representing a distance of 50 ft. or 100 ft. or more.

In conclusion, I am of opinion that Mr. Watermeyer's method of averaging samples, while extremely ingenious, does not take into consideration the root of the trouble. Before attempting to apply any debatable method of averaging values, we should investigate fully and eliminate as far as possible the considerable errors introduced by factors such as those outlined

above. No matter what method is used to find the most probable average value represented by a number of samples, there can be no doubt that the considerations of tonnage and value referred to must be given due weight. When this is done it will be found that predictions based on the arithmetic mean of sampling results will agree as closely as can be expected in practice with the mill return, more especially when it is remembered that it is a good mine in which the gold content, by volume, is 2 parts per million of ore. In other words, the method commonly adopted for finding the average value of a number of samples is not responsible to any important extent for the discrepancy between the value of the ore mined as determined by the mine sampling and by the mill returns. The discordance is largely brought about by crediting considerable tonnages of waste or very low grade rock with the average value of the current stope sampling, and is further aggravated by actual errors in sampling such as those referred to above.

ANCIENT TIN MINES OF THE TRANSVAAL.

By Max Baumann (Member).

(Printed in Journal, February, 1919.)

DISCUSSION.

Mr. T. P. Waites *(Member)*: Mr. Baumann's paper touches on some matters which may be classed as highly controversial. For instance, one finds therein: Hall opines that the "ancients" were, probably, Semitic. On what authority is not stated. The word Semitic has a very comprehensive application; it is not applied to the Hebrews, or, to the Jews, only, but to Assyrians, Arameans, Ethiopians, Phœnicians, and Arabs. But, until some concrete evidence, some hard fact, such as a skull of one of the "ancients," be found, who these ancients were, and whence they came, may be considered a mystery. Guessing will not solve this mystery, and Hall's statement is merely a guess. Perhaps these ancients were of the same species as the chimpanzees, which, so Stanley and Emin Pasha tell us, go about with lighted torches on their predatory night raids.

It is customary to put down evidences of ancient mining to the time of Solomon—to the Semites. When the riches of Mexico and of Peru were looted by the Spaniards under Cortes and Pizarro (both in the name of the Cross) and in the sixteenth century, so came it were given out, accepted, and believed that each of those lands was the land of Ophir. The Jews never toiled, neither did they (yet, except under compulsion, as in Egypt) and even if some Semitic people did "work" the gold mines of Rhodesia, the tin and the copper mines of the Transvaal, they would work them by proxy, *i.e.*, they would compel the then natives to work, forced or paid work.

So far not any remains of these ancient miners have been found, no burial place, no tangible trace. Again, there are, or were, at Zimbabwe, such evidences of phallic worship, that we have still to bring in agreement this worship with the Semites. One sees such evidences of phallic worship, also, in the Museo Profano at Naples, and in Pompeii.

The peoples of countries so far apart as Egypt, Mexico and Peru made use of bronze implements. So also did the ancient tin miners of the Transvaal. There is not any evidence of any communication between Egypt and Mexico, nor between Mexico and Peru, and yet with abundance of iron about all three made use of bronze tools. It is permissible to suppose that the ancient gold miners of Rhodesia also used implements of bronze. Were the bronze implements in use by these ancient tin miners manufactured on the spot or was the raw material exported and returned as the manufactured article?

Humboldt brought back with him from Peru an "ancient" Peruvian bronze chisel, which, on being analysed, was found to be made up of 94 copper and 6 tin. Mr. Baumann has given us the analyses of the bronze implements of the ancient tin miners. I have not at hand any record of the analyses of bronze tools from Egypt or from Mexico.

A current example of "ancient" mining methods can be seen in Madagascar. Tananarive is that land's Zimbabwe; Europeans its "ancient" miners. Learned treatises are extant showing that the Malagasy are of Jewish—"Semitic"—origin, because of certain prevalent customs and practices. But, the philologist, the anthropologist, the ethnologist, and the measurer of heads come along, and prove, by comparison of living peoples, of skulls, skin, hair, and speech, that the Malgasy are Malayo-Polynesian, and *not* Semitic whose nearest relatives are to be found in the little island

of Nias to the west of Sumatra, 3,000 miles east from Madagascar across the Indian ocean, and on the Continent of Africa, 240 west across the Mozambique Channel, nor in Arabia, to the north, the home of the Semite. Of race and the origin of race, unless we have some hard facts, guessing may interest, but it will not convince.

The Spaniards pursued their search for gold in the Peruvian Andes, for silver in the mines of Potosi, with the accompaniment of most awful atrocities to their Indian workmen. It is probable that the "ancients" pursued their search for gold in Rhodesia, for tin in the Transvaal, by means of corvée or forced labour, or by actual slavery. Permit me here to state that when in my wanderings I landed at Tamatave many years ago, I was told not to go into the interior in search of gold. To find gold, to dig for gold, was then, and had been from time immemorial, a capital crime. Gold, said the Malagasy, would attract and bring to their land the white man, and the coming of the white man meant the end of native control of the island. So it has proved. This is comparable to the tradition among the Aztecs of Mexico, and the Indians of Peru. Whence came this parallel idea of the Hova? Were stories of the ancient gold and tin mines of Monamatoppo carried across the Mozambique, or had tales of the deeds of the Spaniards in the gold and silver mines of Peru drifted across the wide Pacific from island unto island, thence across the Indian Ocean to Madagascar? One language is spoken by all the peoples in all the islands from Easter Island to Madagascar, and these islanders were, and still are, skilful navigators. One interpreter was sufficient for Captain Cook in his long voyages among the islands of the Pacific.

Hall's statement that the "ancients" were Semites appears to me to be about on a par with Voltaire's statement, made in 1768, when he was indulging in abuse of the geologists of that time. Oysters had been found on Mont Cenis: Voltaire is of opinion that they fell from the hats of Roman pilgrims!

I have wandered somewhat from "the ancient tin mines," but the statement, unsupported, that the ancient miners were Semites is, perhaps, an ample and legitimate excuse for my wandering. To me, who these ancients were and whence they came is still a very open question, and will be until facts replace guesses.

The meeting then terminated.

Book Review.

THE CYANIDE PROCESS: ITS CONTROL AND OPERATION. By A. W. FAHRENWALD, E.M., Met.E. London: Chapman & Hall, Limited, 1918. With 37 illustrations, 256 pages, 4 in. x 6½ in. Price 9/6 nett.

This book is not primarily concerned with the details of practical operations, but is rather intended as a laboratory guide, both for the investigation of ores as to their suitability for cyaniding and for the conduct of the necessary tests in an operating plant. It is somewhat curious that the references to local literature are very scanty, and that some loss is incurred by the strict confinement to American practice. For example, Whitby's well known modification of the copper salt method of gold assay is referred to as Clennell's method, and the addition of sodium *sulphate* is recommended by which the whole point of the improvement is lost and correct results cannot be secured.

The determination of available calcium oxide in lime by the method given is not nearly as accurate as more modern methods, and it is a pity that the author has not availed himself of the researches published in this *Journal* on the subject.

The author is still under the impression that oxygen is not necessary for the reaction between gold and cyanide, and quotes the usual type of obviously inadequate experiment in proof thereof. In a section headed "Care of Copper Plates," the use of cyanide is recommended in "a very good wash for general purposes"—a vicious practice long since abandoned in modern plants in this country.

The "student and beginner," to whom this volume is confessedly addressed cannot hope to make much of the following paragraph, which heads the chapter on useful data, without explanation or even comment:—

"Torque units should be distinguished from energy units: Thus, foot-pound and kilogram-meter for energy, and foot-pound and meter-kilogram for torque."

Notwithstanding the defects mentioned, this little book is excellently got-up, with very clean illustrations and considerable freedom from typographical errors, and should prove a very useful help to anyone starting laboratory practice.

H. A. W.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

SODIUM CYANIDE.—"For the past year cyanides have for the first time been sold on the basis of their cyanogen content, the purest technical sodium compound containing 'sodium cyanide 96% to 98%' or 'cyanogen 51% to 52%,' whilst the old so-called '98%, KCN' contained about 39% of cyanogen. Commercial fused sodium cyanide contains only a trace of potassium and not more than 2% to 4% of total impurities. It is largely prepared synthetically by heating sodium amide (produced by the interaction of ammonia and metallic sodium) with carbon. The most recent method of preparing it for the market is to cast it mechanically into egg-shaped cakes weighing 1 oz. For technical purposes the most convenient method of determination is to titrate the solution N/20 silver nitrate solution (1 cc. = 5 mgm. of commercial NaCN), with potassium iodide as indicator. The burette readings then also give directly 'lb. per ton of solution.' For the determination of sodium and potassium in mixed cyanides, in which chlorides and carbonates are the usual impurities, it is often practicable to evaporate the salt with hydrochloric acid, to ignite the residue gently, to weigh the mixed chlorides, and to titrate the chlorine in part of the residue. From these data the proportions of sodium and potassium may be calculated. Alkali sulphides may be detected by shaking the cyanide with fine lead carbonate suspended in water; or by dissolving it in a solution of silver nitrate containing less than 1 mol. $AgNO_3$ for 2 equiv. CN; or by dissolving it in mercuric chloride solution. In each case a black precipitate or dark coloration indicates the presence of sulphide. Sodium cyanide is not deliquescent, and is much more soluble than potassium cyanide. The concentration of dilute solutions may be approximately ascertained by means of the formula—

$$(Sp.\ gr.-1)\times 200 = Gm.\ NaCN \text{ per } 100 \text{ cc.}$$

Strong solutions of sodium cyanide differ but little in stability from those of potassium cyanide; if anything, they are somewhat more stable."—W. J. SHARWOOD. *J. Ind. Eng. Chem.*, 1918, *10*, 292-295. —*Journal of the Society of Chemical Industry*, June 15, 1918, p. 299a. (J. A. W.)

SOME AVAILABILITY STUDIES WITH AMMONIUM PHOSPHATES.—"The commercial ammonium phosphate used was manufactured by the American Cyanamid Company by the following process. Ground rock phosphate was mixed with sufficient sulphuric acid to liberate the whole of the phosphoric acid, which was filtered off. Ammonia, generated by the action of steam on calcium cyanamide under pressure, was bubbled through the phosphoric acid solution until di-ammonium phosphate was formed. Sufficient phosphoric acid was added to convert this into the mono-ammonium salt, and the solution was evaporated to dryness, giving commercial 'Ammo-Phos.' This material contained 13·5% NH_3 and 43% P_2O_5, of which 96·5% was either water- or citrate-soluble. This was compared as a nitrogenous fertiliser with ammonium sulphate, dried blood, and cottonseed meal, and the average nitrogen recovery for six crops on Norfolk sand, ammonium phosphate coming first, was respectively 65·88, 61·10, 43·74, and 41·19%, and on a Sassafras loam 48·46, 50·42, 42·61, 36·14. The crop yields were slower in the same ratio as the nitrogen recoveries, except that under very acid conditions ammonium sulphate frequently showed a higher recovery of nitrogen but a much smaller crop than ammonium phosphate. Ammonium phosphate produced a smaller increase in soil acidity than did ammonium sulphate. There was very little difference in the availability of the phosphorus in ammonium phosphate, acid phosphate (superphosphate), or basic slag. Ammonium phosphate showed about the same toxicity to germination and early growth as ammonium sulphate and less than sodium nitrate or ammonium chloride when applied to soils in high concentrations. Of the crops examined, corn (maize), buckwheat, barley, wheat, and oats were resistant to large applications of fertilisers, while vetches, rape, and cowpeas were relatively susceptible. As a fertiliser ammonium phosphate is in general of the same value as an equivalent amount of nitrogen as ammonium sulphate and phosphorus as superphosphate."—F. E. ALLISON, *Soil Sci.*, 1918, 5, 180.—*Journal of the Society of Chemical Industry*, May 15, 1918, p. 252a. (A. W.)

THE SETTING AND HARDENING OF PORTLAND CEMENT.—"The author summarises the findings of the U.S. Geophysical Laboratory and the Bureau of Mines on the nature of the chief constituents of Portland cement and their influence on the setting process. The essential components of the clinker are CaO, Al_2O_3, and SiO_2, and a good cement can be made from the three pure oxides. In commercial cements other and minor constituents are present, but their influence on the setting is purely secondary. The study of the above mentioned ternary system shows that in a well burned clinker three compounds are capable of a stable existence, viz., $2CaO.SiO_2$, $3CaO.SiO_2$, and $3CaO.Al_2O_3$. If the time and temperature of heating are insufficient, then free lime and $5CaO.3Al_2O_3$ are also present. All these compounds have been identified in commercial clinkers and the first three form 90% of the whole. The hydration of the separate compounds was studied. Lime hydrates to an amorphous product which later crystallises. $5CaO.3Al_2O_3$ with a little water sets rapidly, but disintegrates with excess, partly owing to dissociation and partly to its considerable solubility in water. $3CaO.Al_2O_3$ with water, sets and hardens rapidly, but the product has little strength in water, being comparatively soluble. Probably there is first formed an amorphous hydrate which crystallises later. $2CaO.SiO_2$ sets only after several months, but the product is not very soluble. Free lime is leached out by water, gelatinous silica being left. If sufficient water be taken, the decomposition can be carried to completion—a process which is accelerated by the presence of $3CaO.Al_2O_3$. $3CaO.SiO_2$ with water, sets and hardens rapidly, giving a product of strength comparable with that of good Portland cement. This compound is the essential constituent of a good cement, which contains 30—35% of it. On hydration, free lime is extracted, leaving gelatinous hydrated silica, just as with the dicalcium silicate, but the decomposition is more rapid and can be carried to completion if washing is continued. From these observations it seems that the setting and hardening of cement involve the formation of gelatinous hydrated material which subsequently partly crystallises. The initial set is probably caused by hydration of the tricalcium aluminate. This and hydration of the tricalcium silicate are responsible

for the hardness and cohesive strength at first. The gradual increase of strength is due to the continued hydration of these and of the dicalcium silicate. Gelatinous silica is probably the chief cementing material, just as it appears to have formed the original binder of sand grains in tough sandstones, which are ideal concretes."—G. A. RANKIN. Faraday Soc., Jan. 14, 1918. (Advance proof.) 6 pages.—*Journal of the Society of Chemical Industry*, Feb. 28, 1918, p. 90A. (J. A. W.)

METALLURGY.

SPECIAL GOLD RECOVERY PROCESSES.—"Mr. Kirby Thomas calls attention to the fact, reported by John Mawe a century ago, that Brazilian natives mixed the juice of certain bruised herbs with the water in which they finished the panning of gold from black sand, and also mentions the addition of the leaves of an oak-like tree to *tahones*, or primitive Chilean mills, used for grinding ore in Sinaloa, Mexico. This use of plant juice to facilitate the settling or concentration of "float" gold has been mentioned by several other writers.

Volume 20 of the Proceedings of the Institution of Mining and Metallurgy (1911) contains two papers on the Passagem and Ouro Preto mines in the province of Minas Geraes, Brazil. One of these, by R. H. Kendall, describes (pp. 28-60) the modern treatment of the bismuthic gold ore of Ouro Preto by stamp-milling and concentration on blankets followed by frue vanners. The very rich blanket concentrate (largely free gold) is re-washed over a small blanket, yielding a final concentrate carrying about 80 per cent. gold. "The water used in this operation is a solution containing the juices of the leaves of the *jurupeba*, and is very effective in preventing float gold. . . . At the end of each day's operation the *jurupeba* solution is filtered off by suction and stored for next day."

In discussing this paper, H. L. Sulman, president of the Institution, called attention to the use of this herb—presumably containing saponin—which he interpreted as reducing the surface tension of water. Sulman had previously patented the use of soap solution for settling float gold and slime (Brit. pat. 24,939, of 1893 and 8,405 of 1894). The plant was stated to be *Solanum paniculatum*, of the nightshade or potato family, and also locally called *herva de sabão* (soap plant). Other plants, including a variety of passion-flower, were also said to be employed for the same purpose in the district referred to above.

The same thing had also been recorded by Alexander Caldcleugh ("Travels in South America, 1819-1821": published in London, 1825). A. G. Lock ("Gold," p. 227) says: "The overseer showed Caldcleugh some plants whose juice is squeezed into the bowls containing gold, to carry down the lighter particles. There were several plants in common use for this purpose, but the one generally preferred, from its containing more juice, was called *itabamba*: it appeared to be a Solanum. The leaves had a bitter taste and gummy feel." This was at a place one league from Passagem.

In the Philippine Islands a pod-bearing vine (*Entada Pursaetha* or *Entada scandens*, called *gogo* or *balogo* by the natives) is used in panning gold with the batéa. This contains saponin and was the subject of an investigation and report by the Philippine Bureau of Science a few years ago. It was also mentioned by Lock ("Gold," p. 368).

Something similar has, I believe, been reported as used by the native gold washers of Sarawak (Borneo) and Sumatra; I have also heard vaguely of an herb used by Mexicans in California and Lower California. The latter is probably one of several well known liliaceous plants called soap-root or *amolé*, the roots of which contain enough saponin or allied substance to lather freely with water.

Saponin as an anti-flotative agent has been discussed to some extent by Hoover, Rickard, and other writers on flotation. It evidently occurs in plants differing widely in character and distribution, which include the horse-chestnut and the numerous soap-roots, soap-barks, soap-berries, etc. Its application to float gold appears from the above to be confined to people of a relatively low stage of civilization. That it "works" is evident from its continued use in Brazil for a hundred years."—W. J. SHARWOOD, *Chemical and Metallurgical Engineering*, July 15, 1918, p. 63. (J. A. W.)

TREATMENT OF RADIUM ORES.—"The average radium content of commercial ores is 5—10 mgm. per ton. The treatment aims at first obtaining a barium radium sulphate concentrate, which may be effected by several methods. The ore may be boiled with alkaline carbonate solution or fused with the solid salt, whereby uranium and vanadium are rendered soluble. The residue is leached with hydrochloric acid. In the Radcliffe process the ore is fused with saltcake, the fusion product crushed and agitated with water, and the liquor separated from the heavy unattacked material. The turbid solution is left to settle, when it deposits sulphates of barium, lead, and radium. In the U.S. National Radium Institute, the material is boiled with 40% nitric acid, in which the alkaline earth sulphates are appreciably soluble. The hot acid solution is rapidly filtered under pressure through a plate of "filtros" or alundum forming the bottom of an earthenware filter set in a steel shell. The filtrate deposits barium and radium sulphates. The sulphate concentrate, which should carry 1 mgm. of radium per kilo., is reduced by ignition with charcoal, and the resulting sulphide dissolved in hydrochloric acid. Further concentration is effected by fractional crystallisation of the mixed chlorides, and, later on, of the mixed bromides from acid solution, the radium accumulating in the less soluble fractions."—R. B. MOORE, *Amer. Inst. Min. Eng.*, Sept., 1918; *Eng. and Min. J.*, 1918, *106*, 410-412.—*Journal of the Society of Chemical Industry*, Oct. 31, 1918, p. 626A. (J. A. W.)

A NEW PROCESS OF THE FINE DEPOSITION OF METALS.—"According to the *Zeitschrift für Angewandte Chemie*, a German patent has been taken out involving a new process for spraying metals on to surfaces of any kind. The metal to be sprayed forms one of the electrodes of an arc, and a blast of gas impinges on this electrode, directed, however, in such a manner as not to play on the arc and extinguish it. The gas used for the blast is of a non-oxidizing nature, and its effect is to carry away fine particles of metals, which can thus be deposited on any kind of surface forming a very thin skin. When polyphase currents are used the electrodes may either be convergent or so placed as to cross the streams of gas. In one form of the apparatus the arc is started by means of the instantaneous discharge from an auxiliary high-tension circuit."—*Indian Engineering*, Sept. 21, 1918, p. 165. (J. A. W.)

MISCELLANEOUS

Chemical Engineering as a Profession.—"I know no career which offers more prospects or contains greater possibilities of advancement to a young man who has an aptitude towards mechanics than that of chemical engineering," said one of our leading chemical manufacturers to the writer a few days ago.

He pointed to the giant autoclaves, stills, vacuum filters and compressors. "All these apparatuses, these pumps and conveyors, these retorts and vats each holding hundreds of gallons of acids or alkalis, are the product of mechanical engineering shops. Yet it is safe to say that not one of them could have been brought into existence by either the chemist whose life is spent amongst test tubes in his laboratory, or the manufacturing chemist who measures his products of oleum or nitric acid or betanaphthol by the dozen tons and who handles cyanides, or T.N.T. or dinitrobenzol in commercial quantities, any more than they could have been brought into existence by the unaided efforts of the engineer who designs turbines or locomotives or steel bridges as a part of his ordinary work.

The three components by themselves are of little or no value without the chemical engineer. The student occupied in research, the maker of the machinery, the producer of heavy or fine chemicals need the brain of the chemical engineer before their work can be of any commercial value. And this country is in direct need of well trained members of that profession.

It is not a question of salary; it is not that the reward offered is insufficiently high to be attractive to the educated and intelligent man. It is simply that, before the war the German held the chemical trade of this country practically in the hollow of his hand. The great majority of the chemical engineers were Germans brought into the country to maintain inviolate the secrets of the Badische Soda and Anilinfabrik and the other giant German concerns which were strangling the English industry.

Those chemical engineers of British birth who worked with them studiously kept in the dark as to underlying principles and were deceived as to methods; they were led astray by bogus formulæ and hoodwinked by misleading patent specifications, the result that now we can count almost on our fingers the number of expert chemical engineers in the country. We, in common with every other manufacturer of heavy chemicals, are prepared to pay salaries, which at one time would have seemed fabulous, to men who have a knowledge of applied chemistry, combined with a thorough grounding in mechanical engineering, and who possess the ability to design the sequence of machines by which the manufacturer can make by the hundred tons the compounds that the research chemist can make in the laboratory by the hundred drops!

Under the heading of heavy chemical work comes the manufacture of such mineral acids as hydrochloric, nitric, and sulphuric; chlorine and bleaching powder; Epsom and Glauber's salts, potash and soda; and the production of ammonia, nitrate and cyanamide by the fixation of atmospheric nitrogen. Under that of fine chemical work comes the production of dye-stuffs from the hydrocarbons, benzol and toluenes distilled from coal tar.

The "intermediates" about which we have heard so much and the war brought home to us the fact that Germany practically controlled their manufacture, belong to the same category, as do the high explosives as T.N.T. and picric and trinitrotoluene manufacture and the treatment for the manufacture and its treatment for the manufacture of aniline and dynamite, nitroglycerine and nitrocellulose under the same heading, together with all chemicals used in photography. For one and every person involved in the commercial manufacture of these substances the services of the chemical engineer are required.

Sound Economical Principles.—Chemical engineering problems are constantly arising in the manufacture of illuminating gas and producer gas, their combustion in large gas engines, and the recovery of power from the waste gases of the blast furnace. The thermodynamic explanation of coal in bulk storage to prevent spontaneous combustion, the utilisation of low grade fuels as lignite or brown coal, peat and coal and coke dust, the prevention of smoke, together with the improvement of stoke-hole conditions by flue gas analysis, draught regulation and temperature measurements, are within his province and it has been and still takes power plant practice, so far as heat economy is concerned and the recovery of the by-products of combustion, a properly trained chemical engineer could, in the majority of cases, effect such economies as would result in increasing the efficiency of production by anything from five to thirty per cent.

It goes without saying that the training of a chemical engineer should primarily consist of sound teaching of fundamental principles accompanied with or followed by instruction in the industrial application of these principles. It is common knowledge that hitherto, owing to circumstances quite beyond their control, British manufacturers have been backward as regards research work generally, whilst the industrial side of science has been almost shamefully neglected by our large universities. Many of our leading scientists have not been altogether blameless, either, as they have as a body been prone to hold aloof from any research which savoured of commercialism.

But at least one of our most important technical schools is paying great attention to training students in chemical engineering work, and is affording opportunities to specially capable students to participate in researches conjointly with members of the staff. A number of the leading works are now busily engaged in similar work in connection with their research laboratories, and whilst it is impossible to teach research, all possible is being done to impress its value on the student and indicate to him the general lines he should follow.

What is Profit?—Some little time ago a friend of the writer, Mr. W. R. Cooper, pointed out the importance of the cost factor in the work of the chemical engineer. Could cost be disregarded, his labours would be greatly simplified; by which is meant that there may often be, and indeed are, discovered methods by which this, that, or the other product could be manufactured in fair bulk. But that is insufficient; the processes followed must be those whereby the greatest possible quantities can be turned out at the least possible cost.

Results obtained regardless of cost are of no commercial value.

The idea of introducing, and indeed emphasising, the factor of cost is often distasteful to the teacher, but its importance cannot be overestimated. The chemical manufacturers of this country will be called upon to maintain the position they have won during the past four years against a sharp competition, and the difference of a few shillings a ton in the cost of production may mean the difference between a dominant position as manufacturer or that of a mere huckster, buying the productions of others as cheaply as possible to sell in any market that can be found.

A fundamental characteristic of any commercial product is that it may be sold at a profit and yet, as a rule, the young chemical engineer has little or no idea of what is meant, in the commercial world, by profit. The question of the cost of labour and material, of management, of distribution of the finished product is of great importance, but taken with it must be the vastly more complex questions of establishment charges and overhead expenses, or running costs and of depreciation and appreciation of plant and materials. That is to say that the higher positions in the ranks of the chemical engineers can only be occupied by those men who in addition to their knowledge of engineering and machine design and construction, and of applied chemistry generally, have a sound commercial training and a knowledge of business methods.

Training in Practice and Design.—The chemical engineer, like every other business man, will find that the rich rewards offered are only to be won by painstaking effort and serious application. Recently Dr. Beilby outlined a scheme for the training of industrial chemists which is worthy the serious attention of all who intend taking up the profession of chemical engineer—the only profession, be it remembered, which is not and cannot, for some time to come, be overcrowded. This included a sound and practical training in both pure and applied chemistry extending over a period of three years.

During the third year special subjects should be introduced with a view to discovering special aptitude, and at the end of the third year each student, individually, should be examined by the heads of the departments, his records examined and analysed, and be finally advised as to the particular direction in which he would find it of greatest value to continue his work. A fourth or fifth year would then be spent in higher post-graduate work by those who intended to specialise in more abstruse work whilst those students of only average ability would be specially instructed in generally advanced work.

Together with this work would go special training in general engineering practice and machine design. Descriptions of existing special plant would be dealt with from a theoretical standpoint, and the plants themselves examined and treated from their practical aspect also. Shop instruction in applied engineering work would be essential, and both teacher and student would have to be actuated by the central consideration, that the functions of the chemical engineer are the design and construction of machinery and apparatus for carrying out, on commercial scale, the processes discovered in the research laboratory.

One of the greatest mistakes ever made by a leading scientist was the declaration of Professor Armstrong that chemistry and engineering are antagonistic in character, and that the notion of training chemical engineers should be abandoned in favour of a scheme whereby chemists with no engineering knowledge and engineers without chemical training should co-operate. There has been too much of that co-operation, faulty, half-hearted and beset with difficulties arising from lack of mutual comprehension, in the iron and steel trades, and chemical manufacturers are not likely to risk the pitfalls that have beset the steps of other producers.

The chemical engineer is wanted and the chemical engineer is bound to come—and he will find the world of advancement, with untrodden paths, lying at his feet."—G. Basil Barham, C.E.—*The World's Work*, January, 1919. (W. A. C.

Abstracts of Patent Applications

209.18. Cornelis Fredrik Delfos. Improvements in rock drill valves. 6.4.18.

This application relates to a percussive apparatus having at each end two valve seats connected severally to the two ends of the cylinder and a valve reciprocated between said two seats by difference of pressure brought about by movement of the piston, the use of valves formed of thin plate. In the apparatus as claimed above, a live air chamber surrounding each valve and retaining means for the valve adapted to allow live air to pass freely all about the valve.

Apparatus as claimed in claim 1 or claim 2 in which the valves are disposed parallel with the axis of the cylinder and substantially tangential to the cylinder, and close to the bore of the same.

Apparatus as claimed in preceding claims, in which the cylinder wall is formed with exhaust ports spaced substantially equally to the length of the piston.

210.18. Cornelis Fredrik Delfos. Improvements in rotation devices for hammer drills. 6.4.18.

This application refers to hammer drills and more particularly to the gear for rotating the drill steel, and the peculiar feature on which the patent is claimed is that the piston shank has a straight flute part of a smaller diameter than the helical flutes, the two portions of the fluted cylinders being discontinuous.

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Morse, W. S., *l/o* New York; Seaford, Delaware, U.S.A.

APR 1920

THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA.

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Vol. XIX APRIL 1919. No. 10.

Proceedings

AT

Ordinary General Meeting, April 26, 1919.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 26th April, 1919, Mr. H. S. Meyer (President) in the chair. There were also present:—

18 Members: Messrs. J. Gray, H. A. White, J. Chilton, C. J. Gray, F. G. Macdonald, J. R. Thurlow, G. A. Watermeyer, G. Hildick-Smith (Members of Council), Prof. J. Cellier, L. D. Hingle, C. A. Meiklejohn, S. Newton, A. E. Payne, E. R. Schoch, S. H. Steels, J. Thorlund, C. J. Tutt.

5 Associates and Student: Messrs. J. Gibson, L. W. Macer, J. A. L. Ortlepp, A. Short, J. A. Woodburn.

6 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Ordinary General General Meeting, held on the 15th March, 1919, as recorded in the March *Journal*, were confirmed.

ELECTION OF NEW MEMBER.

Messrs. H. A. White and Jas. Gray were appointed scrutineers. After their scrutiny of the ballot papers the following new member was declared unanimously elected:

WILKES, HARRY R. S., City and Suburban G.M. Co., Ltd., P.O. Box 1026, Johannesburg. Assayer

The following had been admitted as a Student:—

ORTLEPP, JULIUS ADOLPH LEOPOLD, S.A. School of Mines and Technology, P.O. Box 1176, Johannesburg. Student.

GENERAL BUSINESS.

"SAFETY FIRST" IN THE STAMP MILL.

Mr. S. H. Steels (*Member*): Although a device was designed a few years ago with the object of preventing stamps falling whilst work in the mortar box was in progress, accidents still continue, not on account of the unreliability of the device, but through neglect or carelessness in adjusting it. It is to overcome this that an automatic self-locking finger, a model of which is here for your inspection, has been

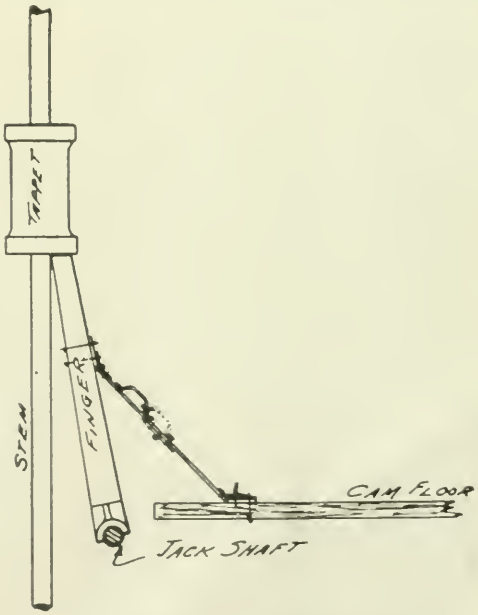

FIG. I.—*Locking Bar in: Stamps Stationary.*

designed. It is automatic and positive in its action, and has the advantage of securing independent units.

The device has been in use for the last

three months at the Village Main Reef, and is used with confidence by the mill employees.

The cost of installing this device is approximately 15s. to 20s. per stamp: the abolition of finger rests and the saving in

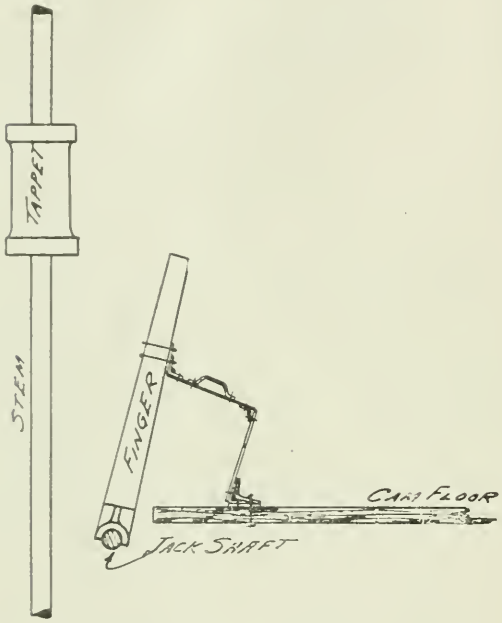

Fig. 11.—*Locking Bar out: Stamps in Motion.*

the life of fingers, will more than justify the adoption of this device. Messrs. W. Hartz, Wessels Vorster and the writer are jointly responsible for the device.

Mr. J. Chilton *(Member of Council):* The device is really a bar equipped with two hinges, which admit of movement in an upward and forward direction.

When it is desired to hang up a stamp the bar is placed in position under the tappet by the hand or foot while the stem is at the top of its stroke. It is impossible for the stamp to drop accidently however severe the vibration in the mill.

Mr. G. Hildick-Smith *(Past-President):* Is it automatically locked when it is put in?

Mr. J. Chilton: Yes, a locking sleeve slips down when the device is in operation. It is the invention of Mr. W. Hartz, an employee of the Village Main Reef, and it has been installed on other mines on the Witwatersrand.

The President: As you know, the exhibition of a device of this character is one in which the Society takes particular pride. We are always looking for anything new, of a practical nature, however small it is. We do not expect to set the Thames on fire, but every time a man who is connected with the industry comes forward here with a practical and useful device, this Society is the first to welcome it and give it the necessary publicity. I hope those who are connected with this particular branch of the mining industry will express their opinions and give their views about it, and tear it to pieces, if they can.

Mr. J. R. Thurlow *(Member of Council):* I would like to say that I have a personal knowledge of the device. It has to be submitted to a practical test for six months on three different mines. I think, in the past, many of us have had experience of inventors nursing their own baby, and, just so long as the inventor was there to nurse it, and care for it, it was always good; but whenever it same into contact with strangers it failed. We are giving this particular device a thorough trial on three other mines besides the Village Main Reef. Personally, I think very highly of it; but it remains to be seen what it will come out like.

Mr. H. A. White *(Vice-President):* I must say there is one feature in this device which distinguishes it from those of a similar character along the Reef: that is, those devices when in use are excellent: but there is no guarantee they will be used.

In this particular case, I understand, if the finger is in use at all, the safety arrangement comes automatically into operation when required. Therefore, it cannot fail because of negligence on the part of anyone, but automatically secures the shiftsman against dangers, even those resulting from his own omissions.

The President: In other words, it is very nearly fool proof.

Mr. S. Newton *(Member):* I agree with Mr. White that there have been ideas on the lines of these fingers for lessening the possibility of accidents, but, although we have had such devices, their working has not been carried out according to instructions. In this particular device it appears that practically no instructions are required, and consequently it appears to be beyond criticism.

AGRICULTURAL MOTOR TRACTORS.

By G. Hildick-Smith, B.Sc., M.I.M.M. (Past President)

During the war I was for some time employed by the Imperial Government as head of the Technical Section of the Food Production Department—a branch of the Board of Agriculture—in that position I had a somewhat unique experience with regard to the working of motor tractors, and, I thought, therefore, that perhaps the following notes might be of interest to farmers and others in South Africa, where undoubtedly agricultural motor tractors will be extensively used in the future.

To begin with it may be interesting, and to some extent perhaps instructive, to describe briefly the work and organisation of the Food Production Department in England.

Not the least of the lessons taught by the war was the use to British farmers of agricultural motor tractors, and from the experience of British farmers, the South African farmers may, I am sure, learn much. Prior to the outbreak of war British farmers, as a whole, condemned tractors generally, but having been forced to use either their own or have Government tractors used on their land, their prejudices to tractors have now been entirely overcome, so much so that at the end of the war, one tractor manufacturing firm alone was supplying at one time as many as 200 tractors per week to farmers in Great Britain, at a time, too, when the Government was operating through the Food Production Department, 4,200 tractors, ploughing roughly about 120,000 acres per month, and this only in England and Wales.

Due to the submarine campaign and consequent loss of shipping, it became essential to produce in Great Britain, as much food as possible, to this end the Food Production Department was formed—this department being responsible for the increased area of land under cultivation in England and Wales—the Scottish and Irish Boards being responsible for the cultivation in those countries.

The Food Production Department commenced work in 1916, and in 1918 the increased acreage ploughed over 1916 was 1,645,000 acres, this being made up of 752,000 acres in wheat, 158,000 acres in barley, and 735,000 acres in oats, thus the above area of grassland had been converted into arable land during the period 1916 and 1918 by:—

(1) Agricultural motor tractors operated by the Government.

(2) Horse ploughing done by Government.

(3) Private farmers increasing their acreage ploughed with their own tractors or horses.

(4) Steam tackle setts.

(5) Tractors operated by private contractors.

At the outset, when the Food Production Department commenced work, it was obvious that if a large increase in the area of land under cultivation was to be made in as short a time as possible, the use of motor tractors was essential. Consequently trials were made with a view to testing the efficiency of various types of tractors and ploughs which could only be obtained quickly in sufficient quantity from America. Having decided to operate a large number of tractors, these were apportioned to each county in proportion to the area to be ploughed—as many as 280 motor tractors were employed in some counties. The upkeep and repairs to the tractors was done by garage engineers, who, generally speaking, at the outset had had no experience with tractors—the upkeep of a tractor being a different proposition to that of a motor car. I mention this point as it had a distinct bearing on the types of tractors purchased by the Government, the most simple and most fool-proof types being adopted irrespective to some extent of their efficiency.

At the commencement the Government purchased many different makes of tractors, which included Parrett, Burford-Cleveland Titan, Fordson, Overtime, Mogul, Saunderson, Clayton & Shuttleworth, Samson, Killen-Strait, Avery and Inter-state.

Owing to the difficulty of obtaining and distributing such a number of varieties of spare parts, the number of types of tractors eventually used was reduced mainly to two —Titans and Fordsons—although, in addition, a certain number of Overtimes, 25 H.P. Moguls Saundersons and Clayton

and Shuttleworths were used, chiefly for hauling and operating threshing boxes.

The Food Production Department was organised somewhat on the following lines:

(1) Cultivation Division responsible for cultivation done by Government tractors and horses, and also responsible for the Government threshing machines.

(2) Technical Division responsible for arrangements as to the supply and advice with regard to fertilisers, and investigations with regard to plant diseases.

(3) Labour Division responsible for the arrangements for the supply to the other divisions of the necessary labour.

(4) Women's Branch, also responsible for the supply of labour.

(5) Finance Division.

(6) Supplies' Division.

The Cultivation Division was divided into the following sections:—

(1) *Technical Section* responsible for the proper upkeep and care of tractors and implements, through the medium of its inspectors, throughout England and Wales; advising on technical questions with regard to the working of tractors, ploughs, harrows, etc., through the medium of its technical advisers, who, when necessary, gave demonstrations on the working of tractors, ploughs, etc.

(2) *Horse Section* responsible for the care and supply of horses for ploughing and cultivating.

(3) *Threshing Section* responsible for the working of the Government owned threshing boxes.

(4) *Administrative Section* responsible for the supply of paraffin and petrol, and for the administrative work in connection with garages from which the Government tractors were being operated.

(5) *Base Supply Depôt Section* responsible for the supply of all spare parts for tractors, ploughs, Ford vans, etc., also for the supply of harness, etc., for the Horse Section.

(6) *Costing Section*, through which figures referring to the cost of ploughing and cultivating in each county were obtained.

In addition to the Headquarters Staff of the Cultivation Division there was in each county a War Agricultural Executive Committee, composed of landowners and farmers, who were voluntary workers, each committee having its staff of secretary, executive officers, supervisors and tractor representatives, who arranged contracts with farmers and the order and price at which contracts were carried out, and, in addition, supervised the tractor drivers, the garage engineers being responsible only for repairs to tractors and the supply of fuel to tractors in the field, which was done by Ford vans, these vans being allotted to the counties in the proportion of one van to every seven tractors, the tractors being operated in units of ten from such garages in the counties as were suitably located with regard to the main arable areas.

The garage engineers were supplied with spares, fuel, etc., free of charge, and only supplied the labour necessary to effect repairs, at a cost of 25/- per week per tractor in commission. It will thus be seen that the organisation was most unwieldy, and as a results very low efficiency was obtained; to overcome this it was eventually decided to loan to garage engineers the Government tractors free of charge, with which they made their own contracts with farmers, thus obviating the employment of endless supervisors, executive officers, etc.

At the end of the war the Government owned about £3,500,000 worth of tractors, implements, Ford vans, horses, etc., and at the prices which they charged for ploughing, which ranged from 22/6 to 35/- per acre, the loss on working was about £1,750,000 per annum, at which cost the food production was however considerably increased and, in addition, the value of the use of motor tractors was proved to British farmers.

Up to the present no mention has been made of the types of ploughs, cultivators, etc., used in conjunction with the tractors. Many of the ploughs used were American types, which turned a much broader furrow than British farmers were used to, the resulting work appearing much rougher than that done by the usual types of English ploughs; the farmers' objection to the broad furrow had, therefore, to be broken down by proving to them that the broader furrow ploughing gave equally good results in most cases as the narrower furrow ploughing. The chief makes of ploughs used were:—Oliver, Self-lift, No. 7, two furrow adjustable plough, fitted with either the No. 221 of No. 115 class of bottom; Ransome, three and four furrow ploughs; Cockshutt, three furrow ploughs, with No. 27 bottom; and Hamilton three furrow, self-lift plough.

The use of tractors in England has been the cause of the self-lift ploughs becoming more universally popular, due to the fact that the use of this type of plough with most types of tractors, effects a saving in labour, the tractor driver being able to operate the plough in addition to driving the tractor.

For cultivating, single and double disc harrows were chiefly used, mainly of the Roderick-Lean type, one or more disc harrows being drawn by a tractor, the number drawn depending on the power of the tractor.

The usual makes of self-binding machines were used, also drawn by tractors. Some types of tractors are capable of running too fast for self-binders. When required, the speed of travel of self-binders may either be reduced by the tractor drawing several binders, otherwise fast types of tractors are unable to run on top gear without shaking binders badly; this happens when self-binders are drawn at a speed exceeding about four miles per hour.

Broadly speaking, there are three main types of tractors:

(1) The Moline, or two-wheeled type (Fig. I.)

(2) The three or four-wheeled type (Fig. II.)

(3) The caterpillar type (Fig. III.)

(1) The Moline, or two-wheeled type of tractor, is so designed that the wheels of the plough or other implement form its rear wheels. The plough used with the tractor is of the riding type, the tractor being operated by the driver from the plough seat: no accident can happen to the driver, driving from this position in the event of the tractor rearing or seat-spring breaking. This is the cheapest type of tractor, costing in England with the plough, roughly, £220. It is a low-powered tractor, developing only about 12 H.P., and is capable of drawing a two furrow plough at a speed of about 2½ miles per hour, the weight of the tractor alone being about 1¼ tons.

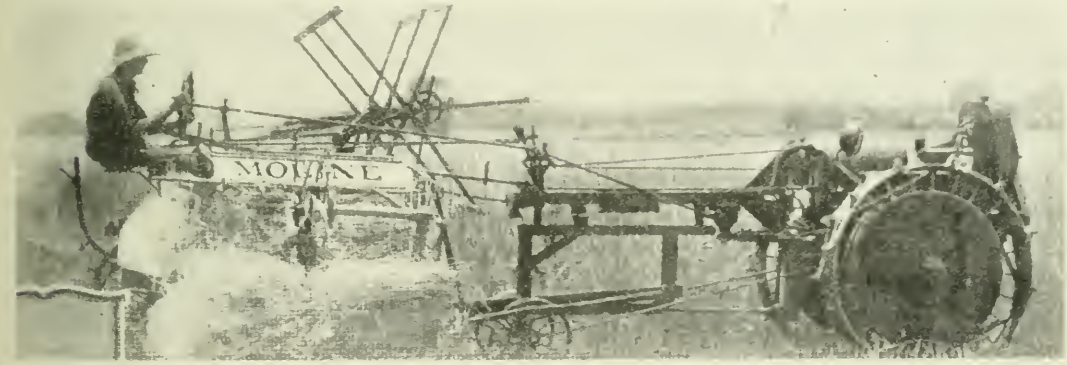

Fig. I.

Tractors are also used to draw mowing machines, and some tractors may be converted into a self-contained mowing machine.

Types of Tractors.—I do not propose to describe any of the varieties of tractors in detail, such information can be obtained from the maker's catalogues. I have only given a general description of the three main types of tractors, of these there are many varieties on the market. It must be remembered that practically all types of tractors—in addition to their use for haulage purposes—can be used as stationary engines for driving dynamos, chaff cutters, filling silos, etc.

(2) Examples of the three and four-wheeled types of tractors are:—The Samson (three-wheel), Titan (four-wheel), Fordson (four-wheel). Such tractors are mostly designed to develop about 25 H.P. and weight about 2½ tons. The cost of the Fordson tractor in England is about £300, and that of the Titan about £600, the latter being the more powerful machine, is capable of drawing a three furrow plough through any class of ground, whereas the Fordson will only draw a two furrow plough, except through light land, when a three furrow plough can be used. The speed of these tractors varies from 2½ to 5 miles per hour. The Fordson tractor is not fitted with a

brake or governor, and is also liable to rear and cause an accident to the driver, if overloaded.

(3) The caterpillar types of tractors, such as the Holt, Tracklayer and Burford-Cleveland, are designed to develop from 20 up to 120 H.P. The design of very high-powered machines being possible due to the weight of the tractor being distributed over the large area of the creeper track, thus obviating packing of the ground when ploughing, etc., the machines being so designed as to give a pressure of about 7 lb. per square inch on the ground. The pull is obtained through the medium of the creeper track, and these machines can work on land in almost any condition.

acres ploughed per day, with a consumption of paraffin of 4·5 gallons per acre, and that of grease 0·5 lb. per acre, the consumption of petrol being 0·5 gallons per acre. These results are below the average which should be obtained; the figures quoted are those for a very large number of tractors which were inefficiently operated.

With a few or single tractors of these types working efficiently, three acres per day per tractor should be ploughed, with a paraffin consumption of about three gallons per acre. For cultivating, the acreage would be double that of ploughing, and the paraffin consumption about half that for ploughing.

With regard to the work which can be done with high-powered caterpillar tractors,

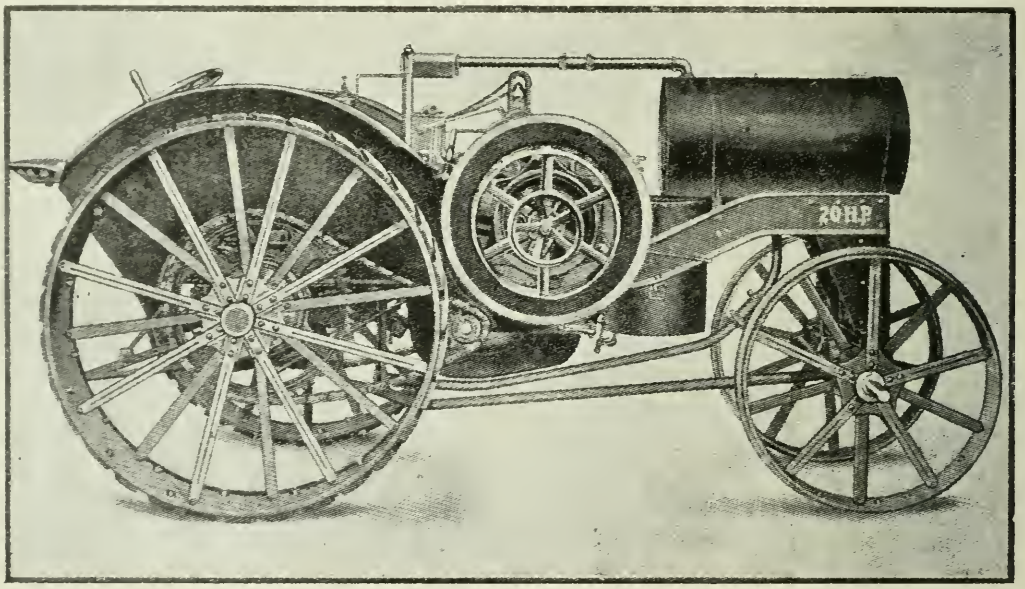

Fig. II.

Of the types above-mentioned the Burford-Cleveland is the smallest, developing about 20 H.P., the other two types are built to develop 40 and 70 H.P., the Holt tractors being built also to develop as much as 120 H.P. The speed at which caterpillar tractors travel is about 2½ miles per hour. The cost of this type of tractor in America would be, roughly, from £400 to £1,200, depending upon the power.

As to the amount and class of work that can be done with the various types of tractors, with chiefly Titan and Fordson tractors the results obtained with the Government machines averaged about 1·75

the following are the actual results obtained with a 70 H.P. Holt caterpillar tractor and these results may be taken as a fair average. The machine was operated by a private contractor in the South of England and ploughed 4,000 acres in fifteen months, the contract price per acre being 19/- with paraffin costing about 1/8 per gallon, the consumption of paraffin being 2½ gallons per acre for ploughing and 1½ gallons per acre for cultivating, a six furrow plough being used. In estimating the amount of ploughing which can be done with this class of machine, as a basis for calculation it is safe to assume, ten acres per day. In

America the contract price for ploughing with high powered caterpillar tractors is about 12/6 per acre, due to the cheapness of paraffin in that country.

It will be seen, therefore, that with regard to ploughing only—so far as conditions in this country are concerned—the work that can be done with the smaller type of tractors, is not sufficiently in excess of that which can be done by oxen to make ploughing by this class of machine economically possible, when taking into consideration the first cost of the tractor, depreciation, skilled labour, cost of fuel, repairs, lubricants, etc.

Thus with either of the usual types of two, three or four-wheeled tractors or the smaller types of caterpillar tractors, such as the Burford-Cleveland, all developing, say, about 25 H.P., it would only be possible to draw up to a three furrow plough—thus on the basis of three acres per day, and a consumption of three gallons of paraffin per acre, assuming the driver's wages at 17/6 per day—it must be remembered that it is cheapest in the long run to employ a skilled mechanic as driver—and the cost of paraffin at 2/- per gallon, the cost of ploughing per acre would be, roughly, 13/-, without allowing for depreciation, cost of repairs and lubricants, which may be taken to be about 8/- per acre, thus giving a total cost of 20/- per acre.

With the high-powered caterpillar tractors the cost of ploughing per acre would be, on the basis of ten acres per day, about 1/6 per acre for wages and fuel, and about 10/6 per acre for depreciation, cost of repairs and lubricants—making a total cost of 15/- per acre. It may therefore be assumed that all tractors of a power below 40 H.P. in South Africa, can only be economically used for cultivating orchards, where the fact that they will turn in a very small space is important—drawing binders, harrowing machines, wagons and stationary engine work.

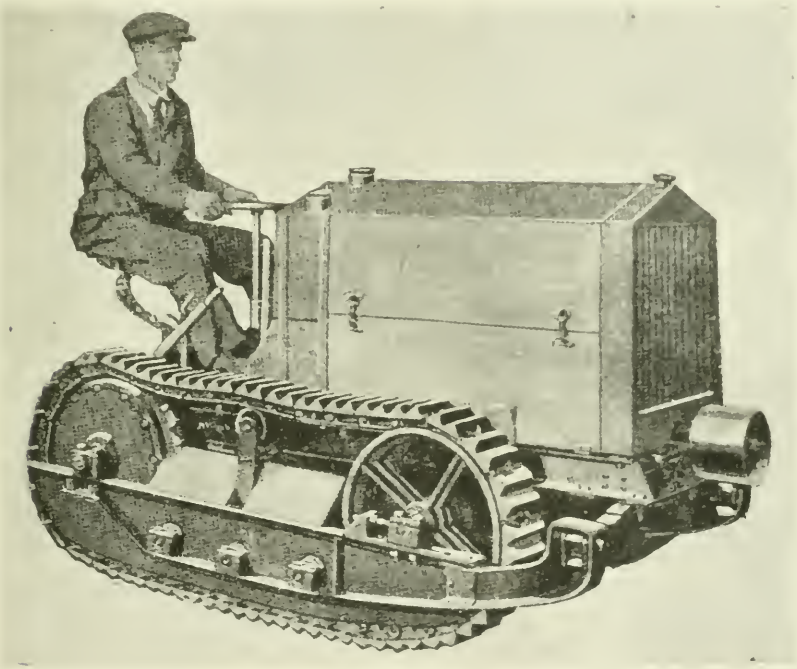

Fig. III.

On the other hand, caterpillar tractors of 40 H.P. and over, can be used on land in almost any condition, and the speed at which ploughing can be done with them, compared with ox ploughing, will make them an economical proposition, even though the cost of ploughing is higher than with oxen. With such tractors sub-soiling can also be done, and, in addition, they will do all the work the smaller tractors will do.

One point should not be forgotten with regard to the use of tractors at high

altitudes, and that is the consequent loss of efficiency, which may be taken at from 10 to 15 at an altitude of 6,000 ft. above the sea level. As the first cost of high-powered caterpillar tractors is high, it is assumed, generally speaking, that neighbouring farmers would co-operate and jointly operate one or more large tractors, either this, or such tractors would be operated by contractors.

Great progress has already been made in agriculture in South Africa, and the introduction of agricultural motor tractors will, I am sure, be a further step in the right direction. There is yet much, however, to be learnt with regard to the use of such machines in this, as in other countries, but it is now possible, if care and judgment are exercised, for farmers to obtain tractors which they will find will be most useful and profitable additions to their farm equipment.

These remarks may, I hope, be of some use in that direction, and this short record of past experience will thus have served some little useful purpose in the future advancement of agriculture in South Africa.

The President: In proposing a very hearty vote of thanks to the author for his very interesting paper, I think it is very apropos, considering that nowadays if there is one thing a mining man thinks he knows more about than anything else, it is farming. Therefore, this up-to-date review of the most modern methods of ploughing must be of very great value.

I feel myself very much at a loss in making any remarks about a subject of this description, because I am one of the exceptions who knows nothing about farming, and I do not expect ever to do so—not at my time of life. But the author's remarks here about the — to put it very delicately — inefficiency of the concern strikes one very forcibly. At the same time, we have to be very thankful that this inefficient work has gradually led to results that must be of great value in the future to those concerned with this class of industry.

I notice that the author points to the value of the head office and about ten different sub-divisions of technical control, which, I am perfectly certain must have led to great economy of administration.

Mr. G. A. Watermeyer *(Member of Council):* In seconding the vote of thanks, I may say that I have a farm of about a hundred acres. I am not doing very much with it, but I shall benefit very much by the author's paper this evening. £600 for a tractor on a hundred acre farm would, however, just about ruin anybody. There is one point I would like to ask him about. How about the sub-soiling? He mentions that the width of the furrow is 14 in.; it struck me that would necessitate a shallow furrow. Can he give us any information as to what depth those 14 in. furrows were?

Mr. G. Hildick-Smith: As to the depth of ploughing, much depends on the class of land and the power of the tractor used —the depth would vary from about 5 to 12 inches. I omitted to mention that with the wheeled types of tractors the "pull" was obtained through the medium of "spuds" or "strakes"—otherwise spikes in or bands placed diagonally across the tyres of the driving wheels—which have to be taken off or covered over when travelling on roads. It may also be interesting to note that to prevent tractors from rearing to such an extent that they fall over backwards, an automatic safety device was used which released the tractor from the implement being drawn, while a somewhat similar device was used to prevent breakages to plough shares in rough land.

NOTES ON THE REMOVAL OF A VERTICAL SHAFT PILLAR.

By J. Chilton (Member of Council).

(Printed in Journal, June, 1918.)

REPLY TO DISCUSSION

Mr. J. Chilton *(Member of Council):* The author is indebted to Mr. J. A. Woodburn for his interesting and suggestive remarks on the paper, and entirely agrees that English mining practice could more often be followed with advantage in our gold mining operations. It should be remembered that in England coal mining has been in operation for over a thousand years, and many of the present-day methods here, have been tried there, found wanting, and relegated to the mining limbo. In roof control this is particularly evident and the idea which dies so hard, that roof pressure should be resisted has in most coal mining centres been abandoned. The long wall system which is followed in most up to date collieries has taught many lessons that could be applied here with profit to both miner and shareholder. There is no doubt that the Village Main Reef shaft pillar was too small for the depth of the shaft, or

otherwise it would not have collapsed, but the difficulty is to find out, what area of protection should be left. Leave an extensive and rich pillar, then a large sum of money is locked up for a number of years with consequent loss to shareholders; leave a small one, and the continuity of operations is likely to be interrupted by collapse due to thrust and creep. In the writer's opinion it would be better to leave no shaft pillar at all where rich ground surrounds the shaft, but to start stoping operations at the shaft bottom and work outwards, the waste rock from the developing drives could be trammed into this area and packed solidly, and the shaft bottom made secure for all time. Any movement that did occur would be of a gradual character, and this could easily be dealt with. If the shaft came down in a poor area then a large and generous pillar could be left without loss of profit, thus securing protection to the shaft and the main arteries of the mine.

Mr I. Hodges remarks on the new tendencies in coal mining practice are worthy of attention, and indicated the line of thought that is influencing the trend of opinion in Great Britain concerning roof control.

It is the complaint of Mr. B. C. Forrest that my statements seem to lead one to conclude that the shaft pillars advocated by mining authorities are useless. That is certainly my contention for estimates that differ so widely only serve to confuse rather than help. It is unfortunate that the north point was omitted in the illustrations that accompanied the paper, but convention has decided that the top of a map or sketch can be assumed to be north unless the contrary is stated. This convention has been observed in all the illustrations, and readers were credited with having some slight knowledge of map reading. There is also internal evidence in the sketches that would enable most persons with a knowledge of Rand mining to easily find the points of the compass. It is certainly desirable, as Mr. Forrest suggests, that rules suitable to our local conditions should be formulated, but up to the present our local authorities seem to fight shy of the question.

In the opinion of Mr. E. M. Weston conditions on the East Rand cannot be compared with those of the central area but he ignores the fact that while crush and creep are comparatively rare in the middle area, they are common in European mines where flat seams obtain and conditions of dip and depth are similar to those on the Far East Rand. With similar conditions similar results will follow.

Mr. H. S. Meyer indicates the direction in which Rand mining opinion seems to trend, and admits that financial considerations rather than good mining practice limits the size of safety pillars.

In conclusion, the author wishes to thank those gentlemen that have contributed to the discussion, and hopes that at some future time this subject may have the attention it merits.

DETERMINATION OF AVAILABLE LIME IN THE DIFFERENT CLASSES OF LIME SUPPLIED TO RAND REDUCTION WORKS.

By C. A. Meiklejohn (Member).

(Printed in Journal, December, 1918.)

DISCUSSION.

Mr. Jas. Gray *(Vice-President).* While welcoming Mr. Meiklejohn as a new contributor to the proceedings of the Society, my regret is that he has taken exception to what has been for the past six years, a standard method for the determination of available lime, and has endeavoured to upset it with data, which, to my mind, are certainly inconclusive.

Available lime determinations have been the subject of voluminous discussion in our proceedings, and considerable work on the the subject was carried out by the Chemical Sub-Committee of the S.A. Engineering Standards Committee, before the method finally adopted was arrived at.

The departures from the standard method recommended by the author are essentially:

(1) Finer grinding.
(2) Reduction in time of agitation.
(3) Standing overnight before drawing off sample for titration (instead of filtration).

Table No. 1, which deals with 1 and 2, requires further explanation. For example, it is not stated if the samples used in the experiments were only crushed to pass a 60 mesh sieve, as required by the "Standard Method," or whether they had been ground finer by the agate mortar. If they had been agated the experiments are not comparable with the "Standard Method," and it of the fineness required by the "Standard

Method," they only prove that agating is unnecessary. There are one or two clerical errors in the percentage column, otherwise, I take it that the author reads his burette to the third place of decimals.

Table 2 is unnecessary. It has been conclusively proved in the past that 1,000 cc. of a 2 solution of sugar is satisfactory with 2 gm. of lime. The point made regarding titrating a solution containing suspended calcium carbonate bespeaks a very poor opinion on the author's part of his professional brethren.

Table 3 is also unnecessary. No analyst worthy of the name, takes the first portion which filters through. This is always rejected, and the reason is obvious.

Deleting therefore, the first 50 cc. in series 1 and 2 and the first 100 cc. in series 3 and 4, we find that what is credited to "the absorptive effect of filter paper," is merely due to the well known absorption of CO_2 from the air by lime water.

As in two cases further filtration shows results differing by 0·2 lower (0·071 cc. N/10 acid), a difference of this magnitude is obviously experimental error.

The author recommends standing overnight before titrating. It is well known by those familiar with lime determinations, that this tends to give low results, and to my mind the results shown in Table 1 confirms this. If six hours' agitation is excessive and gives a lower result, surely standing in contact overnight will have a similar effect.

One of the most essential details in the analysis, is the proper standardisation of the acid, and I believe this to a great extent to be responsible for variations in results. I am not surprised to find that the author's results on titrating solutions with deci-normal sulphuric and hydrochloric acids gave results "practically identical in each case."

In my opinion, the case made by the author for a modification of the "Standard Method" is not supported by the evidence he has brought forward. I do not maintain that because a method has been standardised that it is not capable of improvement, but I consider that it is desirable when such an endeavour is made, that the data supporting it should be of such a nature, that different conclusions cannot be drawn according to the perspective from which it is examined.

THE APPLICATION OF THE THEORY OF PROBABILITY IN THE DETERMINATION OF ORE RESERVES

By G. A. Watermeyer, B.A., A.R.S.M. (Member of Council).

(Printed in Journal, January, 1919.)

DISCUSSION.

Mr. J. Gibson *(Associate)*: The author has undoubtedly opened up a subject which provides material for discussion from a good many standpoints, and, after careful perusal of his paper, one hardly knows from which standpoint to discuss the subject matter without introducing more material collected by different methods to those adopted by him.

Briefly, his paper consists of a mathematical discussion on the probability of recurring events and on applications of frequency diagrams to stope values. It will be readily granted that these frequency diagrams can be obtained in any number, but to apply them, when obtained, in the way suggested does not appear quite logical, nor would it become convincing that they can be applied to deduce a law governing the distribution of gold in the banket beds of the Rand.

Other members have already shown that equally good, if not closer results than those chosen by the author, have been obtained by several mines. Coupled with the explanations they have offered for discrepancies, does there really exist the necessity for introducing the method of least squares? This method is usually applied to the elimination of the "residual errors" of a number of actual observations, but the author does not give reasons why it should be applied to the distribution of reef values in a mine. He states that some method is necessary to bring into balance the discrepancy which exists between the actual recovery in the reduction works and the recovery estimated from the mine sampling, and proposes to apply the frequency curves to effect this. Suppose they be so applied, does their application then, eliminate all the other known factors which also affect the discrepancy? One can at once reply in the negative. It is very easy to be misled in dealing with the huge mass of data of varying factors which affect the matter under discussion and because the mine sampling results are most frequently high, any method which will tend to harmonise these results is liable to be

applied. By obtaining from frequency diagrams a low weight for high samples this proposed method has a tendency all in one direction which happens to be the direction desired; but because this happens to be so, are we justified in its use? The chief causes for the discrepancy lie in stope-widths and reef-widths. The latter require very careful watching where leaders are thin and rich.

sections it has been our custom for a good many years to plot on paper the positions and values of sections wherever sampled, and then to group these as regularly as possible to ascertain the mean value of any face. This process has thrown a good deal of light on the trend of values and has been particularly useful in defining the extent of the profitable sections of the various reefs and, as a consequence, also the shape and

Fig. I.

The proposal to use the frequency diagrams invites an enquiry into other methods of dealing with reef values, and it might be of some interest to members if I submit a few to-night.

It has been established that the nearer we approach to regularity in all the details of sampling, the better is the chance of obtaining dependable results. Hence in order to get the best grouping of a series of

size of the blocks to be included in the reserves.

In dealing with particularly high or low values where they occur, it has been deemed best to take check samples at the spot and also a few feet on either side. From these it is easy to work out a mean value for the section before including it in its place for averaging up. Occasionally the high results are confirmed, but more often than not the

corrected value of the section is found to be very much lower than the original. Nevertheless, it is found that these very high sections do exist and are found in consecutive samplings. Thus we are forced to accept them as definite units or facts to be logically dealt with, and we would be glad to have plenty more of them. For the same reason, a tall man in a crowd is a definite unit, but it would be wrong to disregard his existence or, on the other hand, in calculating the average height of the crowd to use the mean between his height and that of any two other persons at a distance on either side of, say, 20 ft., representing the distance between our sampling sections.

A consideration of the height of every individual forming the crowd would give the average height. It is, therefore, unnecessary to introduce frequency diagrams for this purpose. Similarly, in mining we have to reckon with values per ton, and to derive a quantity of gold from a given tonnage of rock. Total gold is the crux of the whole question.

Take another analogy. The Transvaal consists of a number of farms of varying sizes and value. Would anyone attempt to compute its area or value by plotting frequency curves of the individual farms? Or, to put a value per morgen on Standerton farms, based on the value per morgen of the Bushveld? Again the question can be answered in the negative. Thus we conclude the method cannot be adopted to place a value on a mine, a section of a mine, or a stope face, based on the frequencies of values either in an adjoining mine, another section of the same mine or even the opposite face of the same stope.

This latter point becomes clear by a study of the accompanying diagram, which represents a plan of one of the stopes on the Geldenhuis Deep which occurs in the track of a fairly well defined chute of profitable reef consisting of South Reef and Main Reef Leader close enough to be worked as one stope.

The approximate direction of the chute is south-east, and the two reefs have been mined together. Only those sections above 400 inch-dwt. have been shown on the diagram, and the table gives the number and value of sections in each half of the stoped out area. It is fairly obvious then that the frequency diagrams of the western half could not reasonably be applied to values on the east face of the stope as it stands or *vice-versa*. Hence it cannot be used in the determination of ore reserve blocks in which face values are used. For the same reason it cannot be applied to correlate the gold called for from working faces with the gold actually recovered from the works.

The three cross-sections shown represent: first, one across the chute and along the

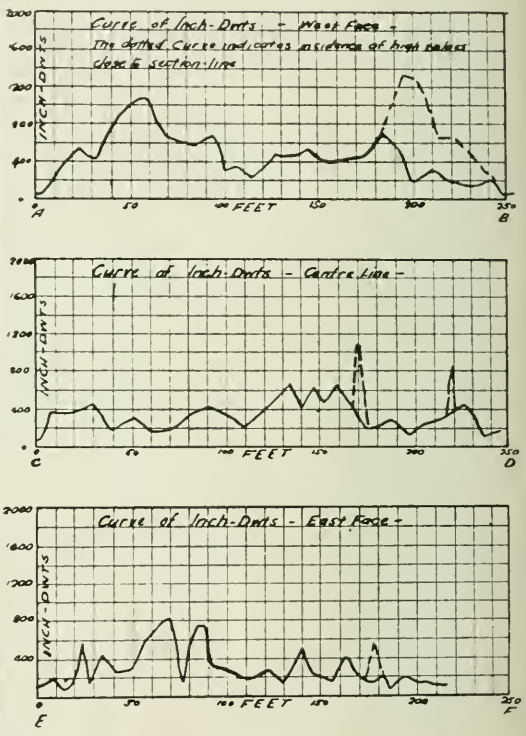

Fig. II.

west face; second, one through the middle of the stope, and the third, one along the east face. In these the ordinates represent inch-dwt. and the abscissae feet drawn to scale. The areas of these represent feet-inch-dwt., and the average value in inch-dwt. can be easily obtained at the respective sections. An inspection will suffice to show there is a marked difference in value between the west and east faces. On the latter the contraction in both ordinates and length of section which could be considered payable is remarkable. Another point to which attention might be directed here is that a series of such cross sections representing values would give a very close approximation of the total gold contents, but again regularity must be observed.

A glance at the table showing the distribution of the higher values will at once show that there is a greater preponderance of high sections towards the west face than near the east face.

TABLE OF DISTRIBUTION OF VALUES ABOVE 400 INCH-DWT.

	Western Half of Stope.		Eastern Half of Stope	
Inch-Dwt.	Number	Inch-Dwt.	Number	Inch-Dwt.
Over 1,000	5	1,190	2	1,130
900-1,000	3	947	Nil.	—
800-900	2	830	1	820
700-800	4	750	4	762
600-700	12	647	5	646
500-600	16	533	4	550
400-500	17	443	12	432
Totals and Averages	59	632	28	598

It may be noted that the average value of the faces in inch-dwt., as indicated on the plan, are those deduced from all the sections from zero upwards, lying within about 30 ft. of the face.

Accepting the fact that frequency curves can be deduced from past results, we would still be justified in not using them since there are other facts to be considered in our attempts to work the mines so as to yield the best profit. It is customary to sample better stopes at longer intervals of time than the doubtful ones. Hence this custom alone would detract from the accuracy of the diagrams. Several other reasons have already been given by other members in their contributions.

It is some years now since the fact began to be revealed that whilst the richer patches in the beds were found in more or less irregular stretches yet these appeared to be arranged along more or less definite zones or chutes. This was particularly noticed where large extents of poorer values had been encountered and the policy was evolved of doing much less exploratory work in these zones, thus applying the practice known as selective mining to the development as well, and there is little doubt that much expenditure in development has rightly been obviated. Within these chutes it can be noted that richer patches exist, but on the whole the gold contents are distributed very irregularly, and whilst we are all agreed that the reconciliation of various data is very desirous, there are so many varying and diverse factors appearing and disappearing that to establish any law which can be applied with certainty hardly seems possible. Hence we are forced to consider every problem on its own merits, and apply to its solution sound principles and reasoning. In dealing, therefore, with stope values, we cannot depart from this practice, and each one must still be considered individually and independent of other stopes. For these and many other reasons it seems inadvisable that the author's suggestions should be incorporated in our practice of valuation. Nevertheless, we are indebted to him for his work, and hope that it will be productive of better methods and results.

In conclusion, I have to thank Mr. Rose, the manager of the Geldenhuis Deep, Limited, for permission to use the data given in this contribution.

Mr. A. E. Payne (*Member*): The object of the author's paper appears to be crystallised in the expression (p. 98, first paragraph of the *Journal*) "we shall have to go farther (than the arithmetic mean) and see whether there is not some law governing the distribution of values which will enable us to arrive at a much closer valuation than has heretofore been possible."

The author proceeds by a very interesting application of mathematical laws to develop a factor by which the occurrence of inch-dwt. values in mine sampling can be weighted so that any erratic tendency in such may be discounted. The process of doing this is most interesting and very clearly set forth, acting as a fillip to all whose exercise in mathematical functions is but rarely called into play, and one cannot but be grateful to the author for such a pretty play of reasoning. However interesting this line of reasoning may be, its usefulness must be judged by its application to know facts, and the results so far obtained from the monthly returns of the several mines mentioned appear to me to err as much on the high side of what is expected from valuation of reserves as were the previous results on the low side.

I am not sure in my own mind that one can apply mathematical laws to the deposition of the gold in the banket beds. The fact is very apparent, however, that there is a remarkable regularity in the deposition of this gold and it may so approach the known conditions of heads and tails on coins, or colour of balls in a bag, to warrant

one applying the mathematical laws to deal with its exposure and the necessary ore valuation. The application of the theory is certainly on the side of probability and can, in my opinion, be allowed to stand the test of time.

A few practical points occur to me to disturb the general criticism that the method of valuation of mean results of samplers' values is not satisfactory.

The author deals with the personal factor of the sampler and assayer and, if I understand him correctly, he minimises their errors by the mathematical application of known law in the theory of errors. But he does not deal with the method of mining the ore so as to discount the irregular supply of the latter to his reduction plant. He takes no account of the fluctuation of native labour in Rand conditions which, speaking generally, results in an accumulation of broken ore in a mine one month and a complete depletion of it the next. Let us imagine this month stretched into a period of months, which in my personal experience is of common occurrence, and where does his percentage recovery of his mine valuation get to then? No mine ever recovers in one month the gold in the ore that is broken in that month. Would the author assume that the swings would balance the roundabouts? I think not, and therefore it must be assumed that the recovery of gold may be only that of a portion of the ore broken in the mine. Since the introduction of water service to the mines it has been possible to wash certain areas of stopes that have been exhausted of ore reserves for years. My recent experience in carrying out this policy may be of interest to members. No sand filling has been done in the mine, and as the area of workings reached a greater depth from the surface and the weight of exhausted areas made itself felt on workings lower down the mine it became evident that the system of supporting the hanging wall in the upper portion of the mine was inadequate to prevent the drag of those workings, when collapsing, nor was it sufficient to give a steadying effect on the hanging wall being exposed lower down. There are always little isolated portions of ore reserves left behind in what are practically exhausted areas, and it becomes some poor mine official's duty to get at those isolated blocks and, when doing so, to have to keep open many levels which show marked desire to crush and cave in. In the course of such exploratory work, we have developed at the Consolidated Langlaagte Mines a complete system of supporting, washing and thoroughly re-examining so-called exhausted areas. Where the hanging wall is comparatively safe, washing, preceded by shovelling any loose rock, brushing and scraping is followed by systematic pigstying, the pigsties being filled with waste rock obtained by breaking up the clean footwall. Where the area shows signs of caving, skeleton pigsties are run in prior to cleaning and washing and are subsequently filled with waste rock.

Our experience of the quantity of broken ore obtained by this method has been astonishing. Accumulations have been discovered which no one knew existed. In one area of about 1,000 fathoms it was calculated that at least a depth of 1 ft. over the whole area was obtained. In addition, and more particularly in south reef stopes, large areas of unmined leader were exposed by this method and ore, which had been included in the estimate of the reserves, had been recovered.

During the process of washing grab samples of the ore are taken by the sampling department and the values returned are as equally enlightening as the quantity of ore obtained.

It is with the question of value that we come back once more to the author's paper. If one can assume that all mines have been more or less so worked and that there are large areas on the Rand unswept, as well as unwashed, there is truly a reserve of gold stored and ready for our calculations which I venture to think will give more solid satisfaction to our Directors than any attempt to explain away the deficiencies in our ore reserve valuation.

We have been carrying out this cleaning work for about 18 months, but though we are breaking about 2,750 fathoms a month at present we have only reached a stage this month of washing approximately the same area. Last month the yield in tonnage from this source was over 6,000 tons. It is too early yet to say what effect the gold so obtained will have upon the recovery value of the mine, but it must be beneficial and, if the areas worked out are systematically cleaned at about the same rate as other areas are mined over an appreciable period of time, one will be in a position to say without doubt that all ore reserves credited to the mine at a certain value has been accounted for and the recovery of gold

represents a certain percentage of that value.

Reverting once again to the opening paragraph of my remarks, it is my belief that before looking to apply mathematical laws to the deficiency of our estimates we should first make sure that we get out of the mine all the ore which we have credited ourselves with.

Prof. J. Cellier *(Member)*: I greatly welcome the author's paper for reasons which I hope I shall be able to explain. First of all, we have here a reef which lends itself to sampling probably better than any other existing in the world. Some parts of it are easier sampled than others, for example, on the Far East Rand where the bed overlies slate and underlies quartzite in the hanging.

When we consider that the highest branches of theoretical and practical mathematics as applied in astronomy and surveying make use of the theory of probability, the practice is also, as shown by the author, readily applicable to sampling, especially when the sampling can be trusted. When values are, in the case of a reef like ours, so evenly distributed, comparatively speaking, then the theory of probability is very excellent. Many calculations can be eliminated by applying an assay-plan-factor, and this is very interesting sometimes, it depending on who is doing the averaging. I have had for many years to earn my living sampling, and for many years after that in lecturing on sampling and mine valuation. Then you appreciate the fact that a mathematical probability is applicable to these calculations also. If the samples are well taken and the calculation is well done, you may find a hundred per cent. recovery; that is metal called for equals metal extracted. Otherwise, there generally is a considerable amount of variation.

I very much appreciated the paper, and I think we owe the author a sincere vote of thanks.

Mr. G. M. Clark *(Past-President of the S.A. Institution of Engineers)* communicated the following:—

I am very glad that this paper has been presented to the Society, firstly because of its intrinsic excellence and, secondly, for two more personal reasons. One of these is, that I was very closely associated with Dr. Troup and Dr. Maynard at the time that they wrote their classical short paper on "Modern Statistical Methods"—which paper has received a very high compliment from the author as he has quoted freely from it, feeling doubtless that it would be difficult to express the elements of these statistical methods more clearly than they have done. This paper is unfortunately somewhat inaccessible, and I hope that in addition to other results the author's paper will lead to this valuable exposition of "Modern Statistical Methods" being reprinted—as it ought to be in the hands of everyone who deals with figures.

In the second place, it happened that some time ago my attention was directed to a method of calculating ore reserves that did not please me, and I had thought of preparing a paper myself on very similar lines to those now followed by the author, but my own paper never arrived, for I had the feeling that the poet had already stated the general proposition in his remarks on the sometimes foolishness of wisdom. He did not live in the commercial age that we now do, and so did not compare the relative advantages of swings and roundabouts in the revenue of a circus, but was content with contrasting a gain of knowledge with a possible loss of happiness.

Whilst everyone connected with mining, from the sampler to the stock-broker, will agree that mining is speculative, they have not the training to recognise that these chances obey laws that can be formulated better than any that the lawyers are capable of drafting. Pope has defined chance as the direction that thou cans't not see; but it does not follow that because thou art blind to these things that everyone else is also walking in darkness. Whilst the laws of probability do not enable us to predict precisely what will happen in any named event, they do enable us to distinguish the things that will happen often from those that occur seldom.

Now the study of probability—that is the study of the chances of things happening often or seldom—must from this elementary notion of what it is, have for its foundation information as to the frequency with which events occur. So the first step in all statistical problems is to arrange the data in the order of their frequency. Mere tables of figures are not statistics, though often confounded with them. Every mining property on the Rand is covered with mountains of these numerical compilations and the proportion of the real statistical work done on them is probably about the same percentage as is the gold in a slime dam. Increasing the size of the slime dam will almost

certainly increase the total gold contents, but will by no means increase the possibility of getting it out. So, too, with statistical work, fresh compilations of figures or more data on any old problem do not necessarily facilitate the solution of the problem. To extract gold from slime requires actions of quite another type from those involved in piling up the dam. The statistical data from a mass of figures can never be extracted unless acted upon by the solvent of greater knowledge. Sampling appears to be a case very much in point. It has always been known that mill returns never agreed as they should do with the results of previous sampling, and efforts have been made to correct this by piling up more and more samples, instead of going to work as the author of this paper has done, treating the samples with the correct solvent and thus arriving successfully at a satisfactory reconciliation. With proper statistical treatment of the samples, it is probable that the cost of the work could be halved and its value much more than doubled.

The results obtained by the author are of interest and value in many respects. One in particular is striking to the statistician, for the author shows that the samples taken from the mines do not lie along one frequency curve but on branches of two different normal curves as they are called.

The chief interest in this point is that it touches upon the line of cleavage between different schools of statisticians. Some lean to the opinion that all frequency curves should be made up of these Normal or Gaussian curves, whilst others lean to the opinion that if a true random sample has been taken, then there should be but one frequency curve, not necessarily Gaussian, passing through the whole distribution. My own leaning is towards the latter mode of thought, whilst the author has accepted the former. I am inclined to think that there is some disturbing cause in the method of sampling that has prevented a true random sample from being taken. Such, for example, as the lack of proper representation of the poorer samples, and I should take the failure of the statistics to fit into a single frequency curve to be a proof of this. It is a hard matter to get a genuine random sample unbiassed by the opinion of the sampler. It is not always recognised that the "bad observation" is just as much a part of a frequency curve that must occur seldom as is the so-called "good observation" near the mean that occurs often. It should be possible to test a sampler by the goodness of fit of the frequencies in his samples to a recognised distribution curve; not by any means the same for different mines or reefs.

This difference of opinion between the author and myself on such a point by no means detracts from the value of the work done, but rather enhances it. More study in the direction that the author has so well begun is certainly needed, both in the testing of samplers and in the interpretation of the random samples. It will be most interesting to see in the discussion how the figures from other groups of mines support these views.

The author is to be congratulated on the practical shape of his results, for he has eventually eliminated all the mathematical treatment and left only a table of multipliers that can very readily be applied by those who have not the requisite equipment otherwise to obtain the "weighted mean" instead of the ill-used "arithmetic mean" which seems to supply all the needs of the mean intelligence. I hope that the author and his assistants will be persuaded to continue this most excellent piece of work. It will certainly have great commercial value—whatever other advantage it may possess in adding to our knowledge even if we have to risk some happiness in efforts to understand it.

Mr. G. J. V. Clarence *(Associate):* In reading the author's paper on the "Application of the Theory of Probability in the Determination of Ore Reserves," the first point which strikes me is whether the premise on which all his elaborate mathematics is based is correct or not. In assuming that the discrepancy between the actual value of the mill yield and that predicted from the mine sampling, is due entirely to the effect of abnormally high values, the author appears to have overlooked the fact that the difference is probably due in far greater measure to other factors altogether such as, under-estimation of stoping widths, and the loss of gold caused by the inclusion of reef and fines in packs and by fines being washed into cracks and depressions in the footwall of stopes and to other reasons. If, however, his principle be looked upon simply as a new method of discounting sample values in order to bring them into closer agreement with actual recovery values in the mill, then it appears to be fairly satisfactory when applied to

stopes and development in which the whole reef channel is exposed in the workings; this, however, is very frequently not the case in actual practice. Where pay reefs have been left in the hanging or footwall of stopes, or have not been fully exposed in development, such should be discovered and allowed for in valuing the ore reserve blocks, but this would not be done under the hard and fast rule advocated by the author.

It appears to the writer that the most important attribute that is required in the estimation of ore reserves is judgment born of experience and knowledge gained in the examination of different mines under varied conditions.

The writer has had considerable experience in the estimation of ore reserves for the group of mines with which he is associated, and has frequently compared the results actually obtained from stoping in ore reserve blocks with those computed from the ore reserve valuation. The fairly close agreement of the values called for from ore reserve blocks with the actual values obtained from them is shown in the following table:—

Mine.	Period.* Months.	Inch-Pennyweights based on Recovery plus Residues.		Percentage Error.
		Ore Reserve Value.	Actual Recovery Plus Residue Value.	
A	9	449	508	+ 11·6%
B	12	395	405	+ 2·5%
C	10	331	330	− 0·3%
D	12	267	289	+ 7·6%
E	4	352	358	+ 1·7%

It will be noted that in four cases out of five the actual recovery plus residue value was in excess of the ore reserve estimate.

*The monthly periods taken vary, as it was desired to give the latest information available for each mine, dating back from the last ore reserve estimate.

It would be interesting if the author in his reply could give a similar statement, showing how his estimates have compared with actual results from stoping in ore reserve blocks.

The statement that "The mechanical work of 'meaning' differs very little in amount from previous custom," should not be allowed to pass unchallenged, for in the simple example, given on p. 106, the work involved in arriving at the mean of 526 is at least three times as great as it would be by the ordinary system. This point is brought up to show that the time factor involved is by no means negligible, and might be sufficient to prohibit the use of the author's method in many cases.

The author's statement, on p. 103, that values occurring in *unprofitable* areas "should be looked upon as very valuable facts to be made the fullest use of in future estimates" is obviously incorrect, as such values must be left out entirely in dealing with *payable* reserves. This is particularly evident in the case of mines of the Far East Rand, where definite pay chutes occur and where the intervening areas are entirely unpayable.

In taking the unit of value as the inch-pennyweight, the author apparently makes no discrimination between varying reef widths and values, and applies the same discount to 3 in. of reef assaying 150 dwt. as he would to 50 in. assaying 9 dwt.

In conclusion, I think we must all feel much indebted to the author for his expert treatment of his subject, and for shedding a new light on certain of its intricacies. It seems, however, that some of his departures from current methods must be scrutinised cautiously and tried well in practice before they are allowed to supersede our present systems.

ANCIENT TIN MINES OF THE TRANSVAAL.

By Max Baumann (Member).

(Printed in Journal, February, 1919.)

DISCUSSION.

Mr. E. R. Schoch (*Member*). Having been for a number of years closely associated with tin mining in the Rooiberg area, and in view of the fact that many of the ancient workings mentioned by the author in his paper were located and opened up under my supervision, and the majority of the implements, etc., which he exhibited, were collected and preserved at the Rooiberg mine, it is gratifying to see that an effort has been made to record the discoveries and to trace their history and origin.

The author's able description and his sketches of some of the old workings are not only very interesting but most instructive, as showing the sort of mining done and the methods employed by the ancients.

Whereas the workings are for the most part crude and primitive, one fact stands

out clearly, and that is, the people who worked the mines, or their supervisors, were very careful observers, and displayed conspicuous ability in their profession. They mined very little waste rock, and scarcely ever left standing any payable ore. As a rule, when they abandoned a stope it was really worked out as far as payable ore contents were concerned.

Dealing with the historical section of the paper, the author gives some very interesting figures relating to the approximate quantity of ore mined and the probable amount of tin recovered therefrom. Personally, I consider his estimate of the average value of the ore mined very conservative, probably too much so. In this connection it may be pointed out that the ore found at Rooiberg near the surface was of much higher grade than the figure suggested by the author; it averaged well over 20% metallic tin, and in the early days of milling operations the treatment of 10% ore was nothing unusual, whilst the average value of the ore milled for more than a year was over 7% for approximately 18,000 tons treated. This included quite a large percentage of waste rock mixed with the ore, which in modern mining is unavoidable. It is in consequence highly probable that the quantity of tin recovered from Rooiberg alone was much more than 1,000 tons of metal, which is the estimate given by the author.

He suggests that the great majority of the tin was turned into bronze. It will be admitted, however, that there is very little evidence to support this assumption, the only direct piece of information available being the discovery of "an unformed lump or ingot of bronze, evidently the result of an overflow of molten metal from a crack in the bottom of the furnace" found on Blaauwbank and the statement quoted from Dr. Theal's book, where he mentions:

"All inland dwellers use this tin, also such "as they buy from us, which they alloy "with copper for the purpose of making "necklets and bracelets. . . . ."

It seems to me that if the bulk of the tin was used or exported as bronze, there would be more traces of this alloy left than indicated, either amongst the natives or in the historical records of the early traders along the coasts. On the other hand, there are several instances mentioned that bar tin had been purchased by the Dutch at Delagoa Bay. Thus, the author quotes from the same book that in 1732 Capt. Van de Capelle reported at the Cape "that he had purchased 56 bars of tin from the natives of Delagoa Bay," and also in Theal's book entitled "The beginning of South African History," on p. 418 it is stated that:

"The Dutch boat *Snuffelaar* sailed on the "23rd October, 1731, from Inhambane "without having done any trade what-"ever, but at Delagoa Bay, where the "*Zeepost* was rejoined, 22 slaves, 1,376 "lb. of ivory and 213 lb. of tin were "obtained. . . . ."

There are no records mentioned to show that bronze had been purchased by either the Dutch or Portuguese

It would also appear reasonably certain that if the Dutch, who were not, strictly speaking, allowed to trade in Portuguese territory, were able to secure quantities of tin from natives, the Portuguese themselves must have obtained by barter much larger quantities than the Dutch.

From the supposition that most of the tin mined was turned into bronze, and that the large quantity (30,000 tons) could not have been used by the Bantu in the 1,000 years since they crossed the Zambesi, the author expresses the opinion that the ancient tin miners may be correlated with the ancient gold miners of Rhodesia, in other words, that they were contemporaneous. In support of this theory he puts forward certain arguments, and on the face of it makes out quite a good case; however, there are some important facts which cannot very well be reconciled with his line of reasoning. Speaking of the Rooiberg area: if the tin workings are of great antiquity, how can it be explained that *all* the implements and relics found in them are of comparatively recent make? (apparently not more than about 400 years, which is the approximate date of the first settlement of the Portuguese on the coast of Africa). In this connection it should be remembered that the stone hammers, chisels, pieces of timber, etc., were not only found exclusively in the highest or lowest sections of the workings; had this been the case it might have indicated widely separated periods of work. The implements, however, are found, as it were, indiscriminately at any depth, and are of the same type of construction throughout, clearly indicating that the period of work did not extend over many centuries.

The well preserved state of the timber, the comparatively thin layers of rust on the

gads and hoes, and the unfossilized condition of the bones found in the workings, all testify to a comparatively recent period of work. In this connection it may be of interest to mention that in the course of removing sand from an old working at Rooiberg an almost perfect human skeleton was unearthed, buried some 3 or 4 ft. beneath the surface. Unfortunately the natives dug their picks and shovels into it and broke it up before the prospector could intervene. The bones, which may still be seen at the mine office, are rather brittle, but otherwise in a good state of preservation, and the teeth are practically fresh. The skull is thick, and according to the local doctor, is that of a Kafir.

Another point, which cannot escape observation, is that none of the ruins of old Kafir kraals on Smelter's Kop, where apparently most of the smelting was done, resemble in the least these, let us say, of Great Zimbabwe; the ruins at Rooiberg are ordinary stone walls undoubtedly built by Kafirs, and such as are found all over the Transvaal. The inference to be drawn is, that either these kraals are of more modern construction and have no connection with the ancient tin mines, or they were contemporaneous with the latter. It is reasonable to suppose that the old tin miners built some sort of quarters, even though only for temporary habitation.

All the above quoted points of evidence, and the entire absence of really ancient relics suggest, in my opinion, the probability that the tin mines are not as ancient as might at first sight be imagined, and that they cannot be classed as contemporaneous with the ancient rock mines of Rhodesia. I incline to view that they are not more than from 400 to 500 years old, corresponding approximately with the date when the Portuguese first settled on the coast of Africa.

As for the ignorance of the modern Bantu in regard to the smelting of tin and bronze, according to history it would appear that the Bantus who occupied these areas some centuries ago enjoyed a higher state of civilisation and had more enterprise than the present tribes who, owing to discord, subjection, and merciless treatment from conquerors, have lost many of the best qualities of their forefathers.

The natives of that period soon got to know that the European invaders wanted gold, copper and tin, and knowing where to find tin, they mined and smelted it and took it to the trading stations for barter. It is, moreover, not improbable that the natives only learned of the value of tin and of alloying it with copper after having come in contact with Europeans, because no mention of tin and bronze ornaments is made in the books referred to by the author, until the beginning of the 18th century. That the natives actually sold bars of tin at the coast as recently as 1732, is clearly shown by Dr Theal in his works already quoted.

It is most unfortunate that many valuable Portuguese archives and records of their early colonial exploits were destroyed in the great earthquake and fire in Lisbon in 1755, as these documents most probably would have shed further light on this interesting subject.

In the circumstances, the matter will always remain shrouded in mystery, and we shall probably never know definitely who these ancient workers were, and the exact period of their mining activity.

The author, however, is to be heartily congratulated upon having given such a carefully prepared and interesting description of the ancient tin mines in the Transvaal, and his paper will form a welcome and valuable addition to the records on this subject.

Mr. C. J. Gray (*Member of Council*): I have some discursive remarks to offer in connection with the author's interesting paper.

FIG. 1

Probably it will be best to refer first to the photographs which I place before you.

The first is a stereoscopic photograph showing the lode in the face of a modern

drive at Rooiberg. The granular structure of some of the stone shows clearly where cassiterite has partially replaced sandstone along portions of the walls of the original fissure.

The second is an ordinary photograph of a modern working on one of the horizontal flats referred to by the author.

Fig. II.

The third is a stereoscopic photograph taken in a narrow flat stope in the Vaalhoek G.M., near Pilgrims Rest. It shows that very narrow stopes can be worked by ordinary natives. The flat stope photographed was not the narrowest at Vaalhoek. I had to squirm through a narrower to the scene of a fall of hanging wall, and found that a foot-rule could nowhere fit perpendicular to the walls; generally the width was 11 in., but in many places it was 10 in. only.

Fig. III

My fourth photograph is a stereoscopic photograph taken in an ancient copper working broken into at a depth of about 65 ft. at Messina. The working was an irregular drive which was highest at the face which was about 12 ft. high. The face and other places where ore remained was green, owing to a thin coating of malachite, but the face showed numerous white gad marks,

Fig. IV.

those not having been coated, though the coating must have been formed since work stopped. A few holes showed the gad to have been sharp pointed and square in section. The gads seemed to have been used without any great skill, a piece having been taken off wherever it could be found, no groove cutting being done. Several stone hammers and two pieces of bush timber were found near the face. The timbers had probably been used to enable the workers to reach the top of the face. The wood had still some strength, but the bark was falling to pieces.

My fifth photograph is a stereoscopic photograph of one of the old timbers from the Messina working, taken on the surface. The stick was 5 ft. 10 in. long and of Mpani wood. Its interesting feature is that while the upper end was cut obliquely by some very sharp implement, such as an axe or adze, the lower end was cut square across by a saw without disturbing the bark.

The Messina working evidently closely resembles the comparatively recent working at Rooiberg described by the author. It

seems sufficiently proved that Rooiberg tin was worked by natives within the past few hundred years, but whether or not there was earlier working is to me still an open question. The main argument for the great antiquity of the working now seems to be that the amount of tin produced must have

Fig. V.

been greater than could have been disposed of within modern times. An estimate of tin produced must at best be uncertain. It is hard to estimate tonnage of ore from old surface workings as it is generally impossible to say how much surface soil overlaid the actual outcrop, and how much of the excavation was due to removal of actual ore, and how much to the running in of sides or to their battering back for safety or convenience. Then it is difficult to estimate the grade of the ore extracted. It is highly probable that old workers would work lower grade ore and narrower veins in an outcrop than they would tackle underground. Certainly it would be easier to crush and wash a good deal of surface ore than to gad out a few pounds of rich ore in some of the workings described. The natural tendency seems to be to make too high an estimate both of tonnage and grade. Perhaps the author will give some further information as to the bases of his estimates. If it is accepted that 2,000 tons of tin was produced near Rooiberg the difficulty of accounting for its disappearance within comparatively recent times does not seem so great as the difficulty of proving that it could not so disappear.

A few years ago it was accepted that tin and its alloys were not known to the Bantu. Now the author draws attention to the facts that tin was traded by natives 200 miles east of Rooiberg two centuries ago, and worked as bronze to the westward a century ago. I find that Hall, in "Prehistoric Rhodesia," p. 93, quoting from Theal's "Records of S.E. Africa," gives two references to pewter, which is an alloy containing 80% or more of tin. "There is also current a coin made of pewter, which they call calaim: it is made in bars," and "pewter they use in bartering, like square money, with a point in the form of a diamond." I have tried to find those quotations in "Records of S.E. Africa," but there seems to be a mistake in Hall's page references, and I have found one only, in Vol. iii., p. 505, which reads, "Pewter they use in bartering, like square money with a point in the form of a diamond on one side, which is done in the melting. Some came in my hands in Sena and Tete, and I should be glad if I could remember the name given to it by the Kafirs." That would indicate that tin was known far to the north-east of Rooiberg. "It seems not improbable that it will be found that till recently tin and its alloys were widespread among the natives of South Eastern Africa. Export through the Portuguese, and more particularly through Arab traders, may well have been much greater than we are aware, and if tin was used by the natives great quantities may have disappeared through burial with its owners, or through burial by them during the various wars which ravaged the country. It cannot safely be said that as natives never wear tin or tin alloys now they never wore them. Certain tribes at certain periods may well have done so. Hall ("Prehistoric Rhodesia," p. 12), says, "The culture of the Bantu varies both in form and degree. For instance, in its form, certain arts and industries of high grade are peculiar to certain tribes, and are unpractised by others." He quotes Dudley Kidd ("Kafir Socialism," p. 231), as saying, "We know that since the sixteenth century . . . the native races . . . . have lost much of the arts and crafts in which they once excelled."

As showing what may have happened in the past, the following extract from Isaac's "Eastern Africa," published in 1825

(quoted in Bird's "Annals of Natal, Vol. i., p. 186), in connection with a visit to the Zulu royal kraal, is interesting:—

"Some years before they had been informed that the natives had dug from the bowels of the earth a mineral which, when melted in their crucibles, turned to a beautiful glossy white, and was worked by them into arm bangles. Before this they had been accustomed to have them made of iron, with which the country abounds. The chiefs abandoned the black metal, and, as badges of distinction between them and their dependents, the former wore the white bangles, and the latter were consequently obliged to wear the black ones.

"At this period a number of the chiefs died. The 'inyangers,' 'angus' wisemen or soothsayers, were ordered to assemble, and immediately to discover the cause of their death. Several people were suspected of having administered poison to them, and were killed without discrimination or without proof of guilt. The prevailing malady by which the chiefs had been carried off still continuing, and innumerable natives having been destroyed under the impression of being the cause of their death, or being according to their designation, "umtogati,' that is, 'evil disposed persons,' they decided that the white metal worn by the chiefs was the cause of the death of that class of persons, which put an end to further executions of the innocent. The individuals, however, who had discovered the metal, and those who had fabricated it into bangles, were condemned and executed. The bangles were also commanded to be returned to the earth, whence they had been taken, and orders were issued that in future no white metal should be dug up without subjecting the offender to capital punishment."

There is another version of the same story which I cannot now trace, but according to my memory, the men who took the bangles for burial were ordered to fill in the mines, and were met on their return journey by an impi and killed so that the whereabouts of the mine should be unknown.

The argument that the early workers in the tin mines must have had greater intelligence and knowledge than the natives of comparatively recent times does not appear to me strong. Natives who could make the gads found in recent workings and smelt tin, bronze and pewter should have been clever enough for any of the work done in the tin mines. In 1911, Mr. Jameson, who was then manager, told me at Rooiberg that when the ancients reached the limits of a pocket they did not follow the line of fissuring in search of more tin. If that is an observation shown to be correct by more extensive recent investigation, it would indicate that the knowledge of the workers was not very great. Perhaps the author can give some information on the point.

NOTES ON ECONOMIES IN HAND DRILL STEEL.

By H. A. Read (Member).

(Printed in Journal, March, 1919.)

DISCUSSION.

Mr. A. E. Payne *(Member):* I did intend to study the author's paper a little more carefully; but a very casual glance at it demonstrates that he has touched on an old trouble which has afflicted mine managers for many years here on the Rand: that is, how to get away from the difficulties of the mushrooming of the shank end of the steel. I am able to corroborate a good deal about his data on the consumption of steel from experiments which I conducted at the New Primrose some years ago; in fact, I used to make a rough estimate from the method of sharpening in vogue that it required about 2 tons of steel a month to keep about a thousand hammer boys at work. The method was the Kimber Drill Sharpening machine. On just a glance at the figures this seems to be borne out by his more careful calculations. I made up my mind that the real solution was, of course, to use a better quality of steel. I do not suppose we shall ever do it on the Rand, because the method of handling a better quality of steel is more expensive, and the cost of drill sharpening would go up, and make it rather prohibitive, compared with the rather rough and ready way in which we use steel on the mines here. I notice he has not missed that point; so I thought possibly the best practical solution would be to find a medium quality of steel. You may possibly remember that just before the outbreak of war some of our German competitors were hawking round some very cheap steel indeed; I think it got down to as low as 3d. a lb., possibly even lower; it may be within the experience of some members; but I know I discarded such steel more than

ten years ago, and stuck to the better class steel of over 1d. a lb., and I am quite satisfied we can get over the mushrooming difficulty by using a better quality steel.

I also went to some trouble over a considerable period to get the smith to anneal the shank end of the steel; but I found that very dangerous, probably because no great amount of care was given to ensure the right temper being given, and the result was that splinters would be flying up in many directions and many natives were seriously injured: and I had to give it up. So I am looking forward with some degree of pleasure to having the author's new invention tried on the mine. I hope it will prove satisfactory, and so overcome one of our great difficulties.

The meeting then terminated.

Correspondence and Contributions.

MINE DUST.

Nearly everyone will agree with the remarks of the President regarding Mr. Innes' supplementary paper on the "Estimation of Injurious Dust in Mine Air," that his reply to his first paper really constitutes a second stage of the subject, and much good will be done by allowing discussion on this second stage, so that when the third stage is reached still more light will be thrown on this most important subject, and everyone connected with mining on the Rand will be better able to arrive at the solution of the dust problem, which is really the end being aimed at.

The writer passes over the controversy regarding the relative merits of the konimeter and gravimetric methods of sampling, but would endeavour to draw some inferences from the published tests with the object of arriving at some definite methods to be adopted to reduce if not to eliminate altogether the dust evil.

In discussing the first paper by Mr. Innes the writer brought forward the important question of ventilation, and he is very pleased to hear that although Mr. Innes says:—"The fact that a well-ventilated place is better than a badly-ventilated place is obvious for reasons given by Mr. Woodburn"; yet a four days' test was tried with the object of determining this opinion, and the result of this four days' test ought to silence for all time the erroneous opinion that increased ventilation by stirring up the dust in a mine may lead to a hurtful atmosphere.

The further test lasting for seven days, as shown in the diagram at p. 140, is a most interesting and instructive one and appears to bear out the previous opinion expressed by the writer, that if the fine dust was treated as a noxious gas and cleared out of the mine by efficient ventilation a better condition would soon be apparent. This diagram clearly shows that at blasting time the fine dust is carried by the return air in excessive quantities for a short period, while most other times, in spite of the 50,000 cub. ft. passing to the fan, the quantity of fine dust is remarkably low. During the working hours of the morning, from 7 a.m. to 2 p.m., there is a slight increase in the quantity of dust compared with the hours from 10 at night till 7 in the morning. This slight increase is no doubt due to the traffic in the stopes and roadways stirring up the accumulated dust, and it is just here where efficient and properly conducted airwways would be very helpful.

Instead of the recommendation recently made that fans may be stopped during blasting time to allow the men to get out of the mine, fans should be increased in speed if possible, and if airways were suitably laid out and separate districts arranged then men should be able to easily reach the intake or rapidly get out of the return airway, and there would be less accumulated dust to be stirred up during working hours.

To secure separate ventilating districts may mean considerable expense for alterations to existing roadways and making bypasses, but the amount of compressed air which would be saved which is at present used, or one might say, abused, for the purpose of helping the ventilation, would go a long way to compensate for this initial expense, and the healthier condition of the mine, as a whole, would lead to increased efficiency all round, so that the formula originally brought forward by Dr. Macaulay and Dr. Irvine does not appear to be condemned as obsolete, but the mine organization is rather to be condemned for not applying the formula in a better and more efficient manner.

J. Allan Woodburn.

Book Review.

HYDRAULIC AND PLACER MINING. By EUGENE B. WILSON. Third Edition, thoroughly revised. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Limited, 1918. With 96 illustrations, 425 pages, 4¾ in. × 7¼ in. Price 13/6 nett.

This new edition of a well known work contains much fresh and valuable material, mostly dealing with modern development in the working of surface deposits steam-shovels, cableways with self-filling buckets, dredges and traction dredges, but special mention must be made of a 37 page article on "Graphical Methods in Hydraulics," contributed by Prof. L. C. Hill. The article discusses the application of such methods of calculation to the flow of water in ditches and in pipes, and contains fourteen sets of curves which should be found valuable by many persons who do not consider their work to be either hydraulic or placer mining. Indeed the book has a wider field of usefulness than the title indicates. At first sight it appears of very limited use in South Africa, where the only important work which the term hydraulic mining suggests is that on the Swaziland tin field, but that view changes when one remembers that hydraulic methods are applied to stripping overburden from tin deposits in the Transvaal, to removing or retreating sand and slime and to sand-filling on the gold mines, and that "placers" yielded £964,574 worth of diamonds in the Union of South Africa during 1918.

It is interesting to note that the author, referring to reworking of "culm piles" or colliery waste dumps, says, "hydraulic mining is now carried on to a larger extent for mining coal in North-Eastern Pennsylvania than for mining all the other minerals in the United States." Though he makes that statement he gives a few lines only to the methods of working these dumps. He ignores all South African work. It is to be regretted that in preparing the present edition the author did not include still more new material of general interest, even if that involved sacrifice of more old material of local interest.

Though there is a good index, lack of system in arrangement of chapters and their contents is a serious defect. Questions of design, construction, maintenance, operation and cost are intermingled. "Survey of Progress" comes under the sub-head, "Hydraulic Elevators," "Drift Mining" is the next sub-head after "Retorting the Mercury," and the method of cleaning the bed rock is found under "Geology of Placer Deposits."

The size, binding, paper and type are all that can be desired in a technical book, but a few of the illustrations might with advantage have been replaced by clearer and more instructive prints.

C. J. G.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

IODIDE COPPER ASSAY.—"In determining copper by the iodide method, the interference of ferric salts may be prevented by the addition of sodium fluoride. A stable compound of ferric fluoride is thus formed, so that no reaction of the ferric salts with the potassium iodide is possible.

After having made several hundred determinations for copper with the following modification of the well-known 'iodide method,' the consistent results obtained as against the electrolytic and the permanganate methods, and the fact that I have not seen the method described in any of the American journals, lead me to take the liberty of bringing it to the notice of other chemists.

The method depends on the action of sodium fluoride on acid solutions of ferric salts, with the iron of which it forms a stable compound of ferric fluoride, Fe_2F_6, preventing any subsequent reaction between these salts and potassium iodide. The affinity of fluorine for iron is so strong that if a solution of sodium fluoride be added to one containing ferrous and cupric salts the latter will be immediately reduced to the cuprous state, or if in acetate solution, cuprous oxide will be precipitated. The idea of employing sodium fluoride to prevent the reaction between ferric salts and potassium iodide occurred to the late R. Wightwick Roberts in 1898, and the process described was evolved by Arthur Fraser, a chemist in England.

The following reagents are required: A standard solution of sodium thiosulphate of such strength, for convenience, that 1 cc. will equal 10 mgm. of copper; a solution of sodium acetate (about one of salt to five of water) and just acid with acetic acid; a solution of sodium fluoride, about 45 gm. to a litre of water. The method is as follows:

Weigh 1 gm. of ore and transfer to a No. 3 beaker, digest with 7 cc. of nitric acid until action becomes quiet, add 5 cc. of hydrochloric acid and a slight excess of sulphuric acid, in order to convert all the bases to sulphates. Evaporate on the hot-plate until most of the free sulphuric acid is removed. Cool, add about 25 cc. water and boil until the sulphates are in solution. Cool, add enough sodium acetate solution to neutralize the excess of sulphuric acid, when the solution will become red, due to the formation of iron acetate. Then add enough sodium fluoride (a slight excess does no harm and is better than not enough) to discharge the red colour. The iron will then be

combined with the fluorine to form Fe_2F_6, which will prevent any subsequent reaction between ferric salts and potassium iodide.

Keep the volume of the solution to about 100 cc., add about 3 gm. of potassium iodide and titrate the liberated iodine in the usual manner with a standard solution of thiosulphate, using starch as an indicator. Observe all the necessary precautions used in the regular iodide method, particularly to keep the volume to about 100 cc., especially in low grade ores, and titrate to get the end reaction and not simply to discharge the blue colour.

In ores with a dark gangue or those heavily oxidized, the end reaction may be slightly obscure. A little experience, however, will soon teach the operator to distinguish between this and the regular end-point; or the difficulty may be removed by filtering off the gangue. In case of over-titration the end-point may be reached by titrating back to blue colour with potassium permanganate, observing the amount, and again titrating with thiosulphate, having determined the value of the permanganate in terms of the thiosulphate solution.

In ores containing lead or bismuth, starch should be added occasionally during titration, as the yellow colour due to the former and the brownish colour due to the latter may be erroneously attributed to free iodine; otherwise bismuth seems to have no effect on the results.

With low-grade ores of 1% or 2% copper, the reaction with potassium iodide is often slow, especially when the presence of a large quantity of iron has led to the addition of an excess of sodium acetate, and the blue starch-iodide colour keeps returning in a disconcerting manner. Thiosulphate must be added, however, until the blue colour remains permanently discharged.

With sulphide ores containing much antimony or arsenic, a slight variation in the process is necessary, as the antimonic and arsenic acids are likely to be partly reduced during drying by unoxidized sulphur and, by reacting subsequently with the liberated iodine, may cause an apparent shortage in the copper contents. It is well, therefore, with such ores, after evaporating to dryness and driving off the residual sulphur, to evaporate a second time with the three acids. Then, after dissolving in water and before adding sodium acetate, a solution of potassium permanganate of a known value in terms of thiosulphate is added, drop by drop, until the last drop permanently changes the green colour to a greyish violet. If the oxidation by the nitric acid has already been complete, one drop of permanganate will be sufficient. Then proceed as before, deducting 0·02% from the thiosulphate reading; or just destroy the violet and bring back the green colour with a delicate solution of ferrous sulphate, and make no deduction.

In making up the solution of sodium acetate and that of sodium fluoride, I have found it best to make them concentrated almost to point of saturation. In evaporating in such large beakers, the usual precaution is necessary of finishing up on a low heat, until the 'spitting period' is over, when evaporation may be made to dense white fumes without further trouble.

This method combines speed with accuracy by eliminating the great amount of manipulation necessary in other methods, as the ore is weighed into a beaker and remains there until contents are washed down the sink. It also furnishes the operator with an excellent method for controls. On account of the prohibitive price of platinum, the method is convenient for the small laboratory. It will save both time and labour for the large laboratory by yielding results that will check with the electrolytic method, with proper care and skill." A. L. BLISS. *Engineering and Mining Journal*, June 29, 1918, p. 1170. (H. A. W.)

PREPARATION OF N/100 PERMANGANATE SOLUTIONS. "The preparation of weak standard solutions of potassium permanganate by diluting stronger solutions is inaccurate, owing to the presence of organic matter in the distilled water. By means of the following method N/100 potassium permanganate solutions which will retain their strength indefinitely may be prepared. A solution of 0·4 gm. of pure potassium permanganate crystals in a litre of re-distilled water is digested for 36 hours near its boiling point in a flask which has been rinsed with the same water. After cooling, and standing over night, the supernatant liquid is filtered with the aid of suction through a Buchner funnel lined with ignited asbestos, and kept in the dark in a bottle, free from organic matter. After standing two to three days, the solution is standardised by adding 10 cc. of 10% sulphuric acid, rendered faintly pink with permanganate, to 10 cc. of N/50 oxalic acid solution, placing the vessel in a water bath at 65° C. for a few minutes, and titrating it with the permanganate solution. A correction is obtained by titrating 10 cc. of the sulphuric acid diluted with the same volume of water."—J. O. HALVERSON and O. BERGEIM. *J. Ind. Eng. Chem.*, 1918, *10*, 119-120.—*Journal of the Society of Chemical Industry*, April 15, 1918, p. 193A. (J. A. W.)

PLATINUM SUBSTITUTE.—"An alloy containing about 11% Pt and 89% Au is being made under the trade name 'Platino.' Experiments show the alloy to be very resistant: it is, however, attacked by sulphuric acid containing nitric acid, but is more resistant to caustic potash than platinum. On heating in a smoky flame, it does not become brittle, as is the case with platinum. Its resistance to fused potassium nitrate obviates the necessity of using porcelain vessels for fusions. The cost is about one-third that of pure platinum."—I. L. B. VAN DER MAROK. *Pharm. Weekblad*, 1918, *55*, 149-151.—*Journal of the Society of Chemical Industry*, May 15, 1918, p. 244A. (J. A. W.)

MANUFACTURE OF ALKALI CYANIDE.—"Calcium cyanamide containing 19% of nitrogen, when fused with sodium chloride and charcoal in a small iron crucible, gives 70% of the theoretical yield of cyanide. The following conditions were found to be most suitable:—A charge consisting of 100 parts of calcium cyanamide, 100 of sodium chloride, 50 of charcoal, and 30 of calcium carbide is heated uniformly, without contact with air, at 940°-950° C. for 5 minutes, the maximum temperature being attained gradually and the charge cooled quickly. The product contains about 20% of sodium cyanide, which is extracted with water or with 50% alcohol. When water was used as the solvent the yield of cyanide was 40% of the theoretical and when alcohol was employed the yield was 70%."—S. URANO. *Kogyo-Kwagaku-Zasshi* (*J. Chem. Ind., Tokyo*), 1917, *20*, 1309-1340.—*Journal of the Society of Chemical Industry*, June 15, 1918, p. 299a. (J. A. W.)

METALLURGY.

Amalgamation before Cyaniding.—"One of the chief advantages accruing from the practice of milling in cyanide solution is the intimate contact resulting between coarse metal and solvent, caused by the action and operation of the grinding machinery. This advantage shrinks in importance in the case of amalgamable ore when consideration is paid to the fact that milling in cyanide precludes the possibility of the practice of amalgamation, or renders its function only partly effective. If any quantity of the metal in an ore can be obtained by a simple and direct method, an explanation is needed for the substitution of a complicated solution alternative which actually recovers only a proportion.

In the case of gold ores, and in spite of clear enunciations of the actual facts disclosed by milling results, a good deal of misapprehension exists; and the question has been complicated and the issue beclouded by reference to the efficiency of amalgamation with unamalgamable gold ores. Such considerations do not affect the question. If a proportion of the gold in an ore is amalgamable, then practically 100% of this proportion is recoverable. If cyanidation replaces amalgamation as a treatment process for this proportion, then only from 90% to 95% is usually recovered.

The arguments advanced in favour of part amalgamation have, as far as I am aware, been used only as referring to amalgamable gold; and it is therefore untenable to claim that this gold may not amalgamate. In special but exceptional cases the recovery of gold by cyanidation may reach 97%, but in no single instance has a recovery of 100% been recorded with any professional claim to verisimilitude. These facts may be substantiated by milling barren material similar in physical characteristics to the ore usually found in gold-treatment plants, and mixing with this a proportion of coarse gold recovered by the amalgamation process. No matter how fine the ultimate division of the mixture, there will remain a small percentage of the original amount of gold, associated with the gangue, after complete milling in cyanide and filtration treatment on a working scale.

A second method of beclouding the issue is to draw attention to the total amount of gold dissolved or extracted by cyanide and to ignore the question of recovery. Finely divided gold may be completely dissolved in a cyanide solution, and thus completely extracted from the ore; but when associated with gangue as an average grade material, such extracted gold cannot be completely recovered by any combination of known metallurgical processes operating on a working scale. All or nearly all the gold may be dissolved and a high percentage may be recovered as bullion. The loss of the balance influences the contention in favour of efficient amalgamation of gold ores."—A. W. Allen, *Met. and Chem. Eng.—Engineering and Mining Journal*, September 21, 1918, p. 531. (H. A. W.)

MISCELLANEOUS

Health of Silica Workers.—"A measure affecting the refractories industries comes into operation in England on January 1, being a scheme of compensation by the Secretary of State, in pursuance of the Workmen's Compensation (Silicosis) Act, 1918. The measures adopted are calculated to attain the object of ameliorating and protecting ganister miners and silica workers from the adverse results of unhealthy occupations. Medical evidence leaves little doubt as to the effect of inhaling silica dust, and it was claimed that a mortality of 37·5 per 1,000 prevailed amongst silica workers, whilst that of the general inhabitants was 17 per 1,000.

Rules have been promulgated which largely remove danger to health, and the scheme provides that the refractories industries shall compensate its employees. Provisions are made that the afflicted shall be compensated similarly to workers injured by accidents. An appointed medical officer, in pursuance of the scheme, may certify death or disablement due to silicosis, and the worker or his dependents become entitled to compensation. The amount in case of death or total disablement is to be in accordance with the provisions of the First Schedule of the Workmen's Compensation Act, 1906, but there is another and important provision by which the medical officer may certify for a man's suspension from work, and compensation paid him. Where the appointed medical officer certifies that the general physical capacity of the workman for employment is not impaired by reason of the disease then, if the workman is unable immediately to obtain other suitable employment at a not less rate of remuneration, he shall be entitled for a period of two weeks from the suspension to a weekly payment equal to the full amount of his wages, and thereafter if he is still unable to obtain such employment, the Joint Committee shall have power to direct payment to him for further period or periods of unemployment, not exceeding eleven weeks in all, 50 per cent. of his average wages, in accordance with the provisions of the Workmen's Compensation Act, 1906. Again, where the medical officer certifies that the general physical capacity of the workman is impaired by reason of the disease, the workman shall be entitled for a period of two weeks from the date of suspension to a weekly payment equal to the full amount of his wages, and thereafter to such weekly payment, while impairment continues, as the Joint Committee may fix, having regard to the degree of impairment reported by the medical officer, and to the other circumstances of the case, in accordance with the provisions of the Workmen's Compensation Act for fixing compensation in cases of partial incapacity.

The scheme provides for the formation of a fund by subscriptions by all refractories industries employers to a mutual trade insurance company, registered as The Refractories Compensation Fund, Limited. Every employer in the industry is to subscribe in the form of annual subscription or otherwise, and give any guarantees such as the Company may, with the approval of the Secretary of State, determine; and any sum due by an employer to the Fund may be recovered summarily as a credit debt.

Medical officers are to be appointed by the Secretary of State for the purpose of making examination and giving certificates on such terms of remuneration as the Secretary of State may approve. The worker may look upon the periodical examination as an interference with his liberty, and this may cause resentment.

In its inception this scheme, like all others, will no doubt, meet difficulties. Neglect of enforcing rules to subdue or remove dust will automatically cause employers to increase their monetary subscription to the fund, and this will tend to prevent neglect. Medical examination will bring home to the workman the necessity of avoiding inhaling dust."—*The Iron and Coal Trades Review*, Dec. 20, 1918, p. 696. (J. A. W.)

Report on the Trade of South Africa for 1917.—"The year 1917 was a notable one from the point of view of industrial development, which for the first time was placed on a national basis. A census of industrial production was instituted; a Federation of Industries was formed and affiliated to the British Empire Producers' Organisation; the Industrial Development Company was floated in order to provide financial assistance for new industrial enterprises; the Industries Section of the Department of Mines and Industries with its advisory councils was thoroughly organised; *The South African Journal of Industries* was published for the first time; and new companies were floated to establish vital primary industries, notably the production of iron.

Chemical industries are well represented in the list of new enterprises, for these include the manufacture of carborundum, calcium carbide, alcohol motor fuel (in addition to methylated spirit and industrial alcohol from sugar cane refuse), asbestos goods, paint and distemper from local materials, maize starch, stearin, sulphate of ammonia, shoe and floor polishes, wattle bark, etc.; the refining of arsenic and antimony, tin smelting and recovery from scrap, and lead corroding for white and red lead. It is also proposed to manufacture acetone, paper, tartaric acid, and condensed milk, and the production of oxygen is being extended. In addition, salt is being refined from local saltpans, and carbonate of soda deposits, chrome ore, magnesite, mica, and pyrites are all being worked energetically. The most important of the industries is undoubtedly the iron industry, but in the connection the shortage of good coking coal is noted. Mining has been comparatively normal.

With respect to fertilisers, agriculture has been heavily handicapped by the scarcity of phosphate; basic slag has been practically unprocurable and the importation of superphosphate from Japan was cut off during the year. The absence of Indian bone-meal has been balanced by an increased supply of local abattoir refuse. Sulphate of ammonia, now being manufactured in Natal, has been shipped to the sugar growers in Mauritius as it apparently does not suit African soils. The question of a home production of phosphatic manures is receiving serious attention; in the event of recent discoveries of rock phosphate proving adequately rich an expansion of the sulphuric acid industry is bound to follow.

The following table shows the distribution of the import trade in the years 1913, 1916, and 1917:—

Year	Total Imports	U.K.	India	Australia	Canada	Total British Empire	Germany	U.S.A.	Japan.
	£	%	%	%	%	%	%	%	%
1913	38,526,981	54·43	2·82	5·21	2·22	66·36	8·83	9·52	0·28
1916	38,759,262	58·68	3·75	3·35	2·23	69·37	—	15·67	1·40
1917	34,750,782	52·46	6.13	3·64	2·75	66·55	—	17·92	2·10

Thus the United States has attained the dominant position among the rivals of Great Britain. Of the manufactured goods in which American gains are to be noted, the most important group is 'Iron and Steel,' which alone accounts for £2,[illegible] since the outbreak of the war. Also the imports of baking powder and American [illegible] increased by £17,000 during 1917. Among other [illegible] which the U.S.A. has entered the market for the first time may be mentioned: Acids, caustic soda, disinfectants and dips, drugs, [illegible] and tanning preparations, superphosphates, malt glucose, [illegible] cream of tartar, starch and other [illegible], printing ink, waterpaints and distemper, perfumery, soap and unmanufactured zinc.

The growth in the trade of India and Japan is also to be noted. As progress is made in refining oils, India will probably monopolise the supply of linseed, castor, rapeseed and possibly cottonseed oil. Coir fibre, petroleum and Indian pig iron are also being imported. Japan shows increases in leather manufactures, superphosphates, perfumery, and sulphur. The Dutch East Indies and the British West Indies are responsible for the large increase in the imports of mineral oil; and China has a large share of the trade in cottonseed oil.

The exports during 1917 included: Copper ore and regulus, £976,422; other minerals, £162,178; wool and hair, £9,062,916; hides and skins, £2,637,735; maize and other cereals, £2,229,309; blasting compounds, £525,666; wattle bark and extract, £273,502; and asbestos, £87,000.

A census of industries was taken for the first time during 1917. The published data are somewhat meagre but the following list shows the production of some industries of chemical interest. The figures in parentheses give the value of imports of goods covered by the industry in question in 1916:—Explosives and matches, £1,884,149 (explosives £1,599, matches £1,855); soap and candles, £1,735,389 (£97,012); leather, £475,862 (£120,203); cement, £270,129 (£16,743)."—W. G. Wilkham.—*Journal of the Society of Chemical Industry*, Oct. 31, 1918, p. 401R. (J. A. W.)

Briquetting Turnings without a Press.—"A recent issue of the *Echo de Mines*, describes a process of briquetting borings, turnings, etc., without the help of a press, as practised in a foundry at Cherbourg. About 220 lb. of iron turnings from the lathe, etc., are spread on a platform and mixed with 9 lb. or 10 lb. of cement, moistened with $2\frac{2}{3}$ gallons of a weak solution of muriate of ammonia (about $\frac{3}{4}$ lb. of sal ammoniac to 22 gallons of water). The mixture is well turned over with shovels in the same way as concrete is mixed, and is then filled into wooden moulds (slightly tapered inside) about 8 in. in diameter by about 5 in. high, the finished briquettes weighing about $26\frac{1}{2}$ lb. each. The material is first tamped into the moulds with iron rods, and then well pounded with cast-iron rammers. After the material has set, the moulds are removed and the briquettes are left to dry. To make 700 briquettes a day, a working gang of one man and three women is required. The briquettes do very well in the cupola, and may be used in the proportion of 15% to 20% of the total charge. The cement goes over into the slag and causes no trouble. It is used also as a binder in some French foundries where there are no sufficiently powerful presses to produce briquettes without some binding material."—*Page's Engineering Weekly, (Echo de Mines)*, April 12, 1918, p. 173. (J. E. T.)

Abstracts of Patent Applications

242.18. J. H. Veasey. Improvements in hydraulic feed arrangements for rock drills. 23.4.18.

This application relates to automatic feed arrangements for rock drills of the kind in which the drill is constantly forced against a body of water confined in a feed cylinder, and is allowed to move forward at each full stroke of the reciprocating member by the release of a portion of such water. The application is to some extent an improvement of the application covered by Patent No. 152, of 1917, in the name of the same applicant.

519.18. Edgar Arthur Ashcroft. Improvements in the manufacturing of nitrogen, and the removal of oxygen from mixtures of gases containing it, and the obtainment of useful products of, or resulting from, oxidation and de-oxidation. 23.8.18.

This application describes and claims the use of an alloy of a metal of the magnesium-calcium type with a metal of the lead-barium type for the purpose of removing oxygen from mixtures of gases containing it, particularly in the manufacture of nitrogen or compounds of nitrogen, by bringing the gas in contact with the powdered alloy, as set forth in Patent Application No. 517.18 (in the name of the above applicant). The resultant lead hydrate can be used for the preparation of other lead compounds.

559.18. E. Edser (1), S. Tucker (2), Minerals Separation, Ltd. (3). Improvements in or relating to the concentration of ores. 11.9.18.

This application relates to improvements in the froth-flotation process of concentrating ores.

The principle feature consists of the addition of a small quantity of sodium silicate and a sufficient quantity of other sodium compounds for the purpose of producing a suitable froth for separating lead sulphide from zinc sulphide on a mixed lead-zinc ore.

646.18. T. W. S. Hutchins. Improvements relating to muffle furnaces. 23.10.18.

This application relates to improvements in muffle furnaces used for heat treatment or drying where gradual increase or decrease of temperature is desirable. It comprises a circular type where a series of muffle chambers are grouped around a gas producer with passages arranged so that each chamber can be heated in turn, and the air supplied to the producer is pre-heated by being drawn through those chambers that require cooling.

680.18. General Electric Company. Improvements in and relating to systems of electrical distribution. 11.11.18.

This application relates to systems of electrical distribution, and more particularly to apparatus for generating and distributing alternating currents of electrical energy of high frequency, and has for its main object the provision of an improved apparatus for this purpose. The claims are four in number, and read as follows :—

1.—A system for generating and distributing alternating current energy of high frequency comprising in combination, a high frequency alternator having a group of independent armature circuits, a transformer having a plurality of primary and secondary coils, each of said primary coils being wound of a plurality of independent conductors, and means for electrically connecting each conductor of each primary coil to an individual armature circuit, so that each conductor is directly connected in a complete electric circuit with only one armature circuit.

2.—In the system as claimed in claim 1, independent bus bars electrically connected to one terminal of each of the armature circuits, the conductors of each primary coil being selectively connected to the bus bars so that the conductors of each coil are thereby connected to different bus bars.

3.—In the system as claimed in claim 1, or 2, means including an inductance for connecting each of the primary circuits to ground.

4.—A system for generating and distributing alternating current energy of high frequency substantially as described in the specification with reference to the drawings.

The applicants draw attention to certain difficulties which arise in the construction and operation of high frequency generators and transformers associated therewith, and describe in detail a variety of methods for overcoming these difficulties.

707.18. General Electric Co. Improvements in and relating to circuit interrupters. 25.11.18.

The object aimed at in this application is the positive and immediate opening of the circuit. In place of the ordinary latches, triggers and the like, electric magnets are used to keep the movable switch member closed, the feature of the application being to eliminate the disadvantages which are ordinarily met with in switches constructed with electric magnets, such as the transformer effect which is set up when there are heavy rushes of current or short circuits, having the effect of keeping the interrupter closed for an appreciable length of time. In this application to avoid these disadvantages a conductor is so disposed that the armature of the electric magnet which holds the switch member in the closed position is de-magnetized without appreciably reducing or otherwise affecting the flux. There are other details, such as improvement in wiping contacts.

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Brazier, H., *l/o* New Modder; Ferreira Deep, Ltd., P.O. Box 1056, Johannesburg.

Cogle, C. T., *l/o* Nairobi; P.O. Box 34, Paarl, Cape Province.

Fry, A. T., *l/o* Melbourne; P.O. Box 55, Queenstown, Tasmania.

Heathcote, C. F., *l/o* London; Champion Reef Gold Mine, Champion Reef, State of Mysore, S. India.

Reed, Wm., *l/o* B.E.F., France; c/o El Oro Mining and Railway Co., El Oro, Estado de Mexico, Mexico, D.F.

Smith, J. H., *l/o* Rose Deep; c/o J. B. Kilpatrick, Esq., Annfield South, Machan Avenue, Larkhall, Scotland.

Walton, A. J., *l/o* Germiston; P.O. Box 102, Crown Mines.

APR 1920

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications

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Vol. XIX. MAY 1919. No. 11.

Proceedings
AT
Ordinary General Meeting, May 17, 1919.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 17th May, 1919, Mr. H. S. Meyer (President) in the chair. There were also present:—

21 Members: Messrs. J. Gray, H. A. White, J. Chilton, C. J. Gray, F. Wartenweiler, G. A. Watermeyer, F. W. Watson, A. McA. Johnston, Profs. G. H. Stanley and J. A. Wilkinson, W. Beaver, P. Cazalet, L. D. Hingle, Dr. L. G. Irvine, H. R. Martin, T. G. Martyn, C. A. Meiklejohn, P. T. Morrisby, J. J. R. Smythe, H. R. S. Wilkes.

5 Associates and Students: Messrs. E. G. Bilse, J. A. Boyd, D.C.M., J. Gibson, E. G. Harding, J. A. Woodburn.

5 Visitors, and Fred Rowland, Secretary.

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 26th April, 1919, as recorded in the April *Journal*, were confirmed.

GENERAL BUSINESS.

ANNUAL GENERAL MEETING.

The Secretary: The Annual Meeting will be held on the fourth Saturday in June, the 28th, and not on the third Saturday as is usual.

NEW ASSOCIATE.

The following gentleman has been admitted an Associate by the Council:—

BAKER, FRANK REGINALD, New Modderfontein G.M. Co., Ltd., Benoni. Shift Boss.

HIGHER EDUCATION ON THE WITWATERSRAND.

The Secretary: I have a letter from the Secretary of the Council of Education, Witwatersrand, reading:—

"I am asked to direct your attention to the enclosed letter by the Chairman of Syndic, and Resolution relative to the attitude of the Union Education Department with regard to the provision of facilities for the development of Higher Education on the Witwatersrand. I shall be glad if you will bring this matter before your members, and inform us of any action you propose to take. The necessity for concerted action is urgent."

Mr. G. A. Watermeyer *(Member of Council):* The Council of Education of the Witwatersrand has appealed to us to take a resolution supporting them in their endeavour to obtain greater facilities for higher education on the Witwatersrand. I think it behoves us, as a technical society, to give them all the support that we are able. I have a resolution to propose; but shall first give something of the history, as issued by the Council.

The Council complains very bitterly of the Government handicapping them on every occason. First, at an interview at the School of Mines, held on the 7th October, 1916, the Minister stated there would be no difficulty about the establishment of a first two years of a medical course in Johannesburg. On the 17th December, 1918, in reply to a request from the Acting Principal of the School asking Government sanction for the establishment of a second year's course in Johannesburg, the Minister returned a blunt refusal. On the 18th February, 1919, after various representations had been made to him, the Minister gave his consent to the same proposition in an unconditional and categorical way. On the 7th April, 1919, the Minister stated in the House that

the provision of medical education in Johannesburg would have to wait until the School of Medicine at Capetown had been fully equipped. At the interview between the Minister, the Chairman of the Council, and the Principal of the School of Mines, held on the 17th November, 1918, Mr. Malan pointed out that if the Rand community wished to have an Agricultural Faculty at its University and was willing to pay for it, the Government could not say anything.

On the 14th February, 1919, Mr. Malan, in reply to a deputation of Witwatersrand Members of Parliament, insisted upon the abandonment of the project of a Department of Agriculture at Johannesburg. It appears that this change in the Minister's attitude is to be connected with representations made on behalf of the Agricultural Faculty at Pretoria. This is the more unfortunate at a time when Pretoria is appealing to Johannesburg for support for its exhibition.

With regard to the Minister's refusal to acknowledge the appointment of a Professor of Education at the University College in Johannesburg, it should be noticed that either a Professor or a Lecturer in this subject has now been appointed in all the other Universities and Colleges in the Union. Quite apart from the possibility of recruiting a large number of higher grade teachers on the Witwatersrand and thus supplying a great need, it is a point which needs no emphasis that the number of acting teachers on the Witwatersrand who would reap great advantage from such an appointment would be very considerable. As it is, a large number of teachers are already seeking to take advantage of such temporary arrangements as the Council of the School of Mines has been able to make.

Now the Council of Education appeals to us saying that if the voice of the community is not heard, little or nothing will be done by the Union or the Provincial Government to provide adequate educational facilities for the youth of the Witwatersrand. It appears that, since then, Government has sanctioned the appointment of Professors of Anatomy and Physiology at the School of Mines, and that medical students will be able to take their course up to the second year. That is, after very hard fighting on the part of the Council of Education.

We have obtained so much, but we want to go further and have a Faculty of Agriculture on the Rand. It does not necessarily follow because agriculture is practised in the country that the best place for education is not in the centre of a town. We have all the professors of the allied subjects, and the student would be able to complete his course here, more especially with regard to veterinary science. We have all the facilities for educating veterinary surgeons in conjunction with this new Medical School, and it will enable an amount of £10,000 to be used which Sir Owen Phillipps has given to the Rand, unconditionally, I understand, which we have not been able to do up to the present. The Minister does not want us to be rivals to Pretoria in agriculture. Yet we are the larger community and contribute in various ways about 60% of the revenue of the country. So the least the Government can do for us is to allow us to have an agricultural chair here.

Then we come on to teaching. There is a Normal College for teachers here, and it appears that the highest grade to which a teacher can go is the "T.3," which happens to be the lowest teachers' diploma. After that, teachers are required to go over to Pretoria to qualify for the T.2 or T.1 certificates. There is absolutely no reason why, since we have a higher Technical College, we should not have a Professor of Education to allow the youth of Johannesburg to be educated professionally as teachers here. The resolution which I wish to propose is:—

> "That this meeting of the Chemical, Metallurgical and Mining Society deeply regrets to find that Government has shown in the past and is still continuing to show, little or no sympathy with the aims of the community on the Witwatersrand for higher education *in situ*, and protests against the impediments emanating from Government to the development of higher education, especially with regard to the professions of medicine, agriculture, and teaching."

Mr. H. A. White *(Vice-President):* It is an extraordinary thing that this, the real capital of the country, should carry so little weight in the councils of the Government of the land This, perhaps, may partly be attributed to a certain absenteeism, such as Ireland has suffered from for centuries. The principal owners of our wealth, partly due to the war, are resident abroad, and their local representatives, although admittedly men of high standing and reputation, are not able to give us all the aid we require in obtaining a fair return

for the excessive taxation to which we are subjected. The Minister of Finance calls on Goliath of Gath, but the Minister of Education replies to Bildad the Shuhite. Furthermore, the present political capital appears to view our wants with an unfriendly eye, and here we have the right to call for an immediate change in its unsympathetic attitude. We are, and always have been, willing and anxious to help Pretoria in all its legitimate aspirations and we demand reciprocity. In matters of education we ask for the cordial assistance of Pretoria in our endeavours to secure adequate training facilities for our teachers, and provision in our own University for the proper courses in Medicine, Veterinary Surgery and Agriculture. In addition, we expect Pretoria to freely acknowledge that the Rand is obviously the correct place for the gold refinery and mint shortly to be established.

If we find our reasonable expectations met in these matters, it is certain that Pretoria will be liberally repaid, not only when her exhibition is open for visitors, but, as always, whenever she has just demands in any direction whatever where we can be of assistance. In our Society, though politics are barred, all shades of opinion are represented, and we therefore call upon all local Members of Parliament to study the parable of the importunate widow and the unjust judge and to put its principles into vigorous practice. Having just passed measures to rid the country of some undesired inhabitants, it behoves Parliament to provide us with the necessary means to produce the fully trained citizens upon whom so much of the future prosperity of our country depends.

Mr. P. Cazalet *(Member):* It might interest members to know what took place at the meeting of the Witwatersrand University Committee a couple of afternoons ago, as I do not think that any members here were present, excepting Prof. Wilkinson: and it certainly is informative to know that the University Committee is taking very definite action on the lines of the motion moved to-night.

As you know, probably, an Inter-Departmental Commission has been appointed by the Government to decide on the site for the Veterinary College; it sits in July. That Commission, as usual, is rather heavily weighted in favour of Pretoria: five out of seven of the Committee being practically Pretoria representatives; but we will be very ably represented on this Committee in the person of Professor Fantham, and there is no question but that Johannesburg's case will be put before that Commission very fully. The University Committee has appointed a special Sub-Committee to deal with this matter, and to put Johannesburg's claims extremely strongly and support the same by evidence.

Of course, everybody who has studied Veterinary Education knows that it practically follows parallel and on almost identical lines with the Medical School for the first three years out of a four years' course, and for four years in a five years' course, and, therefore, obviously the site for the Veterinary School is at the place where professors who are instructing the Medical Students are resident,—and that will be here in Johannesburg, or at Capetown; those being the two medical centres which have been decided upon. So we can rely on our case being put both ably and strongly and a very good fight made for Johannesburg to be *the* centre of Veterinary Education; the same Sub-Committee is dealing with Agriculture also on behalf of the University Committee, and they will no doubt also deal firmly with this matter too.

I think that brings the position right up to date, to a couple of days ago. You may rely on it that everything is being done that is possible to get these two subjects equitably dealt with by the Government.

The President: I think we must be extremely obliged to Mr. Cazalet for putting us so much *au fait* with the situation as it stands to-day.

This Society has always taken a very keen interest and prominent part in matters such as have been placed before you to-night, and I am quite sure we shall continue to do so.

I do not propose to ask anyone else to speak to this resolution, because I think it is not necessary. The case has been very plainly put. I shall merely ask you to vote on the resolution, which is proposed by Mr. Watermeyer, and seconded by Mr. White, and further explained by Mr. Cazalet.

The resolution was then put to the meeting, and declared carried unanimously.

On the proposal of the President it was resolved to send copies of the resolution to the Minister for Education and to the Council of Education.

THE HANDLING OF AMALGAM FROM STEAMED PLATES.

Mr. P. Cazalet: I would like to make a suggestion as regards this matter. We know from our experience on the mines that varieties of methods of amalgamation are used. On many mines, in fact, the bulk of the mines, steaming is habitually done, and that was the *raison d'être* of the little note that was given a couple of meetings ago, which was extremely useful and interesting; but we also know that there are certain mines which never in their history have done any steaming at all, and have no accumulation of gold on their plates. I can name two mines to-day that, for the last twenty-four years, have never done any steaming except as a proof of the presence or absence of gold on the plates. And therefore I would suggest that it might be referred to the Council as a recommendation to appoint a small Committee of investigation to collect data as regards amalgamation, including the many small variations of practice, and, from amongst the members select one or two, to collate the results of this investigation in the form of a paper, so that it may be definitely recorded what are the practices on the Rand, and how far steaming is a necessity and how far it is a frill.

We know that the question of treatment, or rather protection against salivation has been taken up very strongly just recently, and that there are several methods suggested for improving that; but there is obviously a better method for eliminating steam and mercury fumes, and that is, not to create them; and, if it is possible to carry on amalgamation, as certain mines do, without ever steaming, it might be well if this Committee that I suggest, investigated the matter to see whether or no steaming is a necessity, and what other practices in amalgamation should either be improved or could be more generally utilised on the Rand. So I should like it to be a suggestion to the Council that such a Committee of Inquiry be appointed.

The President: Mr. Cazalet's remarks are of peculiar interest, because this little note about the handling of amalgam has been obviously compiled in order to avoid the danger of salivation from steaming, and I must say I personally agree with Mr. Cazalet entirely—whether he stated that in so many words or not, I think he meant that there was no necessity whatsoever for ever steaming plates. Really, what he means, if I may interpret it perhaps in other words, is this, that he does not regard the plates in a mill as a bank, and I heartily endorse that view.

I think that if that point is agreed upon, then his suggestion that we should go into the question of methods of amalgamation is quite unnecessary, because they constitute a perfectly normal routine; but, as long as metallurgists will insist on keeping so much gold up their sleeves, then we shall always have the unpleasant necessity of dragging it out of him by the teeth—by steaming the plates.

Mr. T. G. Martyn *(Member):* May I ask if there is a great secret about the way this is done, and whether the secret can be revealed?

The President: No, I do not think there is any secrecy about it whatever; it is a matter that is known quite well to nearly every man sitting here this evening.

Mr. P. Cazalet: I might mention the names of the two mines to which I referred: the Ferreira Deep, Ltd., and the Wolhuter Gold Mines, Ltd., have never steamed in their existence, except experimentally to see what gold is on the plates.

The President: The one is a relatively rich mine, and the other is a poor one; they represent very fairly the two extremes, do they not?

Mr. P. Cazalet: Yes.

Mr. H. A. White *(Vice-President):* It is not necessary to use steaming in order to get the bulk of accumulated amalgam off the plates; there are other methods. I think it should not go forward from this Society, as its studied opinion, that steaming is the principal source of salivation and damage to the teeth and jaws of our reduction workers. Other sources, I think, are far more important. The handling of mercury or amalgam and the eating of food thereafter without first completely removing all traces of mercury from the hands is, I think, a more likely source of the trouble that is found in some cases.

Mr. E. G. Bilse *(Associate):* The Knights Central Company never steams its plates. There is another place where mercury may be absorbed, and that is the amalgam press. Some places use hot water, and I think mercury is inhaled there with the steam coming off the hot water.

The President: I think we may very well adopt Mr. Cazalet's suggestion of bringing this matter before the Council, and possibly forming a small Sub-Committee to go into this matter. So I think we can leave the subject at that stage for the present.

A SAFETY DEVICE FOR EXHAUSTING MERCURY FUMES DURING STEAMING OF AMALGAM PLATES.*

Mr. J. Fairfax Walker *(Member):* At the suggestion of the Metallurgical Department, Rand Mines, Ltd., experiments were carried out about six months ago at the Consolidated Main Reef Mine with a view to preventing the mild forms of mercurial poisoning occasionally occurring and contracted whilst steaming amalgamating plates. A simple device was tried and found to be effective; so much so that after thorough trial it has now been permanently adopted on this and a number of other Witwatersrand mines.

From samples taken during steaming operations with the new device, and analysed qualitatively, it was found that mercury in very small quantities was present in the steam exhausted from the plate. Mercury was also found in the air immediately above the plate during scraping, but as the sample was taken very close to the plate and the workmen are generally 20 in. or 30 in. away, the evil results that might accrue are considered negligible.

Gold leaf showed no discoloration when held ¼ in. over a freshly steamed plate, even after the amalgam had been scraped with a chisel. A condenser was placed at the exhaust pipe with the object of recovering mercury, but nothing of commercial value was collected. It is found that the men can now carry out steaming operations with much greater comfort and with safety.

The old method of steaming plates common to most mines, is to have a wooden box, or cover, placed over the amalgamated plate, with the usual inlet of steam. The sides are jammed with sacks, or blanketting, with a view to retaining all the steam, but this is the only outlet, and the result is that, except in the well-ventilated plate houses, mercury laden steam pervades the building, and when the steaming cover is removed, the conditions are even worse, as the workmen have to handle steaming sacks and steam is still present under the cover.

The new device adopted to combat these conditions, consists of a clamped-down cover made in two sections (for a 12 ft. × 5 ft. table. The top of the cover is made of 20

General view of Fume Extractor.

*Owing to a misunderstanding, this note did not come to hand until after the meeting.

gauge galvanized iron, bolted on to a wooden frame, on the bottom of which is tacked thick Kafir blanket, horse rug, or any such material. This cover is placed on the plate with four pieces of angle or channel iron, two for each section of the cover. Then hook bolts are fixed to the frame below the plate, and the screw portion being slipped into slots in the angle iron is fastened down with fly nuts. This makes a tight joint between cover and plate.

A 1 in. steam connection is fixed to the top section of the cover, passes inside, and spreads over the full width of the plate by means of a perforated pipe. A pressure of from 5 lb. to 10 lb. is maintained. The steam is drawn off through a chamber, tapering in diameter from 11 in. to 4 in., by means of a canvas hose 5 in. in diameter. A 1 in. spiral wire is run inside the hose to stiffen it and the outside is given two coats of oil paint to make it steam tight. The connection to the permanent 3 in. suction is made by means of flanges. The fumes are exhausted through the roof by an induction fan which, on this plant, is placed outside the building. An air or steam ejector has been found a satisfactory substitute for the fan.

The method of operation is as follows:—

The fan, air or steam ejector, is started and steam turned on at from 5 lb. to 10 lb. pressure for the required time, *i.e.*, 10 to 15 minutes, after which the steam is turned off the flexible steam pipe disconnected, hook bolts and angle iron stays taken adrift, and water drain pipe plug at bottom end of cover taken out. The fan, or ejector, is kept going until all the fumes are eliminated, then the top section of the cover is raised ½ in. for two or three minutes to allow fresh air to enter under cover and drive out the last of the fumes. Lastly, the flexible hose pipe is disconnected from the cover, and when the latter is removed there is not a trace of fume to be seen, the atmosphere being quite clear and sweet.

The advantages of the device are: First and foremost, safeguarding the health of the men operating on steaming amalgamated plates. Secondly, the amount of steam used is much less than formerly, owing to its being evenly distributed all over the plate and concentrated under cover. Thirdly, the fixing of the device and steaming of the plate are done in less time than by the old method.

The cost of operating is small, while the cost of installation is not great, considering the benefits to the men to be derived from it. On this plant the cost of installing all but the fan was under £100.

It was generally accepted that a plate which is steamed occasionally is in better condition from a recovery point of view than a "dry chiselled" one. The writer understands that several mines will now go back to the steaming process, which was discarded owing to the inconvenience of the old steaming box.

Acknowledgment is due to the practical collaboration with the writer, in designing and carrying out of the trials, of Mr. D. C. Bowen of this mine.

PLATE STEAMING BOX AND MERCURY FUME EXTRACTOR.

Mr. J. Chilton *(Member of Council)*: read the following contribution:

Mr. J. J. Smythe *(Member)*: In view of the escape of steam containing mercury, in quantities detrimental to the health of men engaged in steaming amalgamated plates, it was thought necessary to devise some means of overcoming this undesirable feature.

A method designed by Messrs. Walker and Bowen, of the Consolidated Main Reef G.M. Co., is apparently the first attempt to deal with the situation. When given the privilege of seeing this elaborate installation in operation it appeared to do its work in a very satisfactory manner. It was considered, however, that under existing circumstances the Village Main Reef was not justified in going to the expense of such an elaborate plant as that on the Consolidated Main Reef.

The steaming box and mercury fume extractor under consideration was devised to do away with an expensive installation of piping and a power driven fan for exhausting the steam. As the accompanying illustration shows, the apparatus consists of an ordinary steaming box with a patent 6 in. H.A.S. blower fitted to the lower end of the bottom half of the box and open to the interior of the same. This blower has a nozzle of ⅛ in. diameter, and consumes at 80 lb. pressure 21·2 cub. ft. of free air per minute. In operation it is only necessary to turn on sufficient air to cause a vacuum strong enough to prevent steam leaking from bad joints caused by irregularities of the

surface of the amalgamated plates and full on for a few seconds when steam is turned off from the box in order to clear out any remaining vapour. Where air is unobtainable, steam can be used in the blower. The whole operation of steaming one plate should not cost in air consumption more than one penny, if as much. At the Village Main Reef a short piece of pipe, 8 ft. long, joined on to the blower carries the steam outside the building containing the plates and exhausts to atmosphere. Contact between the box and plate is made by sufficiently weighting them down with moveable weights. No attempt has been made here to condense the steam from the box and so recover mercury carried off, it being understood the quantity is too small for it to prove a commercial success in view of the cost of providing and running a condensing plant.

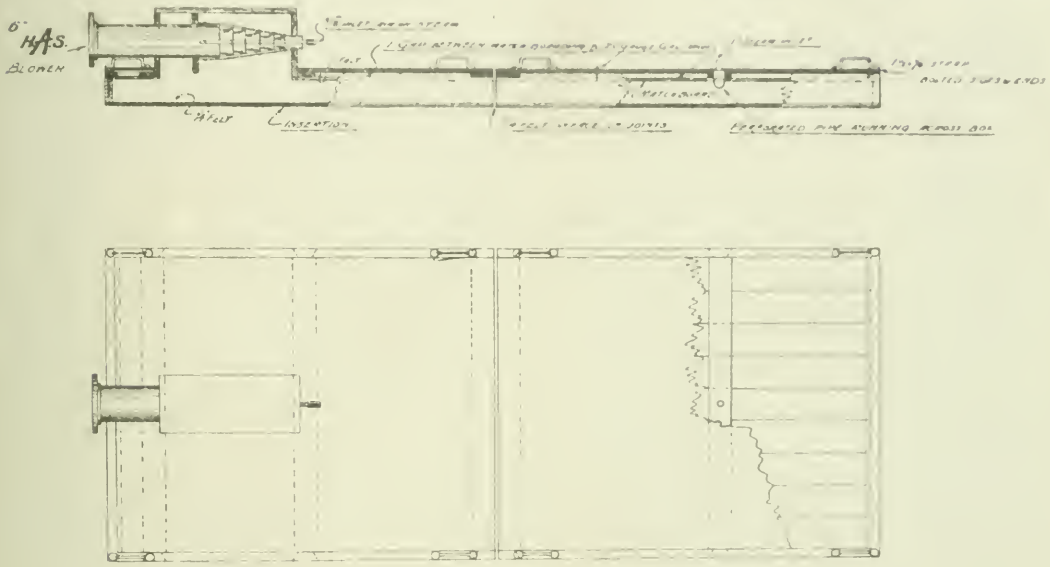

PLATE STEAMING BOX & MERCURY FUME EXTRACTOR

As a result of the experience with the 6 in. blower it is considered that a 4 in. would be ample to do the work, and thereby save in weight and cost as follows:—

6 in. blower, approximate cost, £12; approximate weight, 33 lb.

4 in. blower, approximate cost, £10; approximate weight, 22 lb.

Mr. F. Wartenweiler *(Member of Council):* I would like to make a few remarks about Mr. Chilton's description of this new refinement of device for exhausting mercury fumes. I might state that in connection with the original apparatus, the Consolidated Main Reef device, a fan was first used; also an air ejector, also a steam ejector, and that they all worked about equally well. I think you will find that on one of the other plants an ordinary air ejector is in successful use now.

The President: We greatly appreciate this note of Mr. Smythe's which will no doubt lead to the publication of further short notes on other contrivances used either on the surface or underground. They are most useful.

"SAFETY FIRST" IN THE STAMP MILL.

Mr. E. G. Bilse *(Associate):* I would like to say that I noticed in the *Journal* last month that safety blocks to fingers on the stamps had been in use for the last couple of years. I am inclined to think there are a couple of other necessary things which have been neglected in most mills in the past; firstly, the jack shafts are always put too close to the stamps causing the fingers to stand nearly upright, consequently it does not take much to make them shift out; secondly, the finger-caps are not always given sufficient attention.

Those caps, with the lifting of the stamps, get worn, and, instead of the angle being sloping backward, it soon slopes forward, which assists to force the finger to work its way out, especially where there is any packing. That plays a great part as regards the fingers, and it is a thing that is not attended to in most mills as it should be. I consider that if these smaller things had more attention paid to them there would be far less accidents in the mill, even with all their safety devices. I would suggest that the mill carpenters should receive instructions to examine and overhaul these devices at least once a week.

The President: I am sure we are very much indebted to Mr. Bilse, who has not been very long a member of this Society, and therefore we welcome very much the fact that he immediately comes in and speaks his mind and brings forward practical suggestions, which we value very much.

NOTES ON THE CLOSER WORKING AND JOINT HOUSING OF TECHNICAL AND SCIENTIFIC SOCIETIES ON THE RAND.

By Percy Cazalet (Member).

Before I start reading the paper, I would like to say this paper is not my own alone, and it does not profess to be. It is merely my bad fortune that I was elected Chairman of the Sub-Committee that made the investigation, and other members of the Sub-Committee were sufficiently smart to think it was the duty of the Chairman not only to get the paper together, but to read it. I congratulate them on having got out of a considerable amount of work. At the same time, it is a subject that has been very close to my heart for many years, and I really am not in the least sorry at having the duty put upon me; but I would like to make it quite clear that this suggested scheme is the work of the Sub-Committee representing the three Societies:—this Society, the S.A. Institution of Engineers, and the South African Institute of Electrical Engineers, who have been jointly represented, for most of the time, by three members each, working as a Sub-Committee on this matter for four and a half years.

Throughout the civilised world men and women have always striven after new means of improving the condition of their fellows, of extending the amenities of life and of increasing economic efficiency wherever possible: this is perhaps truest, in later years, of the scientific and technical world, although true also in greater or lesser degree of all ranks of thinkers and workers.

For this movement we have to thank in the first instance the fact that for a long time all the various sections of mankind have been consciously or unconsciously striving, some blindly but some with very definite vision, towards the realisation of a broader, more generous and more corporate life.

The anxieties and experience of the four and a half years we have just passed through will have been without their lesson to us, if we do not see in them not only an excuse for but also a mandate to a less selfish and self-centred life on the part especially of those best able by character, attainment, or the accident of position, to help their fellows.

It must be admitted that the present is a particularly appropriate time to initiate any scheme whereby these tendencies towards co-operative action can not only be realised by all, but also encouraged and guided into such channels as will ensure fruitful results.

Efforts in Other Centres.

In the technical world we see these tendencies largely developed in efforts at more corporate life and closer relations amongst their several societies. In the States, in quite recent years, a central technical house has been secured in New York, largely through the generosity of one of America's leading philanthropists. This institution is owned and used by the engineering societies as their joint house and headquarters, and from it goes forth to the whole country the corporate views of engineers and professional technical men generally, with a weight and clarity which is not possible when each society is interested in the immediate concern of its own members alone and there is no general mouth-piece to speak for the technical and scientific professions as a whole. (See Appendices I., II. and III.)

In England the same tendencies are at work, and *pourparlers* have been exchanged and plans discussed for closer working and joint housing amongst several of the leading societies, with headquarters in London. (See Appendices I. and III.)

In Germany, as anyone who has studied the bulletin of the American Institute of Mining Engineers for August, 1918, will see, a movement has been on foot for some time, but on a much more advanced basis even than the ones mentioned, for there what is proposed is practically an amalgamation, federation and trades union of all societies and those interested in engineering in any form. (See Appendix IV.)

There must be many other similar movements in the world that would prove interesting to consider, but time does not allow of their discussion even were data readily available, but sufficient has already been said to indicate that similar movements to our own are taking place in various parts of the world, and that we cannot be considered to have originated the idea but merely its local application.

History of Local Efforts.

Quite early in the war a movement took shape locally towards the closer working and joint housing of technical societies with a view both to cheapening the cost and to increasing the amenities given to members in return for their subscriptions: it was felt also that such a movement once consummated must lead in a number of ways to the heightening of the standard of attainment of members of the scientific and technical societies, and to an increase of their status and with this last, the trustworthiness of and therefore the reliance placed upon, scientific and technical men generally.

In the first instance a small sub-committee representing the three strongest local and purely technical societies was called together at the instance of the S.A. Institution of Engineers, and much spade work and sifting of schemes and ideas was carried out by them, which efforts and work deserve the gratitude of members of their own and of all kindred societies. When a certain point had been reached last year it was felt that the time was not propitious to go beyond the preliminaries during the anxious days of the last year of war, but now that the war is happily over it is unquestionably the time to consider and, if found feasible, go forward with a definite scheme dealing with all South African purely technical and scientific societies; thus trying to develop further the corporate sense and professional status amongst their members (to the importance of which reference has already been made) by granting facilities for meeting with their fellows under circumstances of comfort goodwill and atmosphere, congenial both on social and professional grounds.

The preliminary discussions soon showed that there were definite difficulties as well as definite advantages, as was of course to be expected in any scheme of closer working, and that it were better to go forward, in the first instance at any rate, on lines which might, it is true, eventually lead to true federation of societies, but with no *arrière pensée* on the subject either of federation or amalgamation.

No society with a worthy history behind it but has reason to shun the loss of identity involved in 'amalgamation,' while an immediate 'federation' would not greatly aid in bringing about the desired end, and it is quite conceivable that before it came about considerable differences would have to be overcome; differences of detail might possibly even overshadow points of major importance on which agreement was movement by precipitate action.

With the present tendencies towards federation of representation and the collection of all with similar interests, as, for instance, in Labour circles, into societies of operatives, a similar tendency amongst the engineering professions is not only conceivable, but is actually probable in course of time, for the tendency of the world is more and more towards the consideration of corporate views as opposed to the views of the individual or of a section.

Nothing of this advanced nature is even suggested in the present scheme to be outlined to-day, but thinking people should see and note these tendencies and should recognise what are the real trends of thought and action, and they then will be in a position to aid, combat or direct them as their experience and desires indicate.

Outline of Scheme.

The outline of the proposed scheme provides the same freedom of action as each society has always experienced, together with the possibility of full 'amalgamation' coming voluntarily when the time is ripe, and the considerable probability of some scheme of 'federation' evolving itself

before many years have passed from the mere fact of joint and harmonious action over a period.

Briefly, the scheme proposed may be outlined as the joint ownership of an Institute building containing offices for each individual society, as well as for the secretary and staff of the Institution itself; large and small meeting halls; reading, smoking and refreshment rooms, with a nucleus of a good scientific library. The possibility of ultimately housing the central scientific and technical library of South Africa when the Seymour Memorial Library eventually comes home to roost in its true dovecote, would also have to be provided for, and, if bedrooms for members from a distance could be included, the convenience of the Institution to such would be greatly increased; were it possible also to provide accommodation in the building in excess of the societies' first requirements, professional men might be taken as tenants of offices, thus centralising the business efforts of unattached professional men as well as those of their societies.

Membership of the Institution would belong of right to all members of such societies, but need not necessarily be confined to them, and members of such kindred societies as might not be eligible for full participation in the scheme, might be admitted to partial or complete membership of the Institution on equitable terms.

The control of the Institute would be in the hands of a committee consisting of representatives from all the participating societies.

Such a broad scheme as has here been sketched in the veriest outline would retain to each participating society its own full and complete freedom of policy and management, together with a share in the management of the Institution itself.

Advantages.

It would not be difficult, given ample time, to give a very complete and detailed list of benefits accruing from such an Institution as is here proposed, but it suffices now only to mention a very few of the obvious ones, namely:—

1. The possibility, if desired, of the joint use by several societies of one secretary, or even of the Institution itself as its secretary. This possibility must lead to greater economy and efficiency, and might ultimately lead to the joint use of such staff by all societies.

2. The use by right, rather than merely through goodwill, of regular and properly equipped meeting-rooms, in which the papers of the different societies would be read.

3. A central and convenient Technical Library, including current scientific and technical literature, where reading can be carried out under the most convenient and comfortable circumstances.

4. Uniformity in methods of production, advertising and letting of tenders for printing of Journals, with the possible partial or complete joint production of Journals of some of the weaker societies.

5. Simplicity of arrangements for the joint reading of papers of general interest before two or more societies.

6. The possibility of forcible and prompt co-operation when necessary of the whole of the participating societies in joint enquiry or unity of action towards matters of technical or public interest.

7. The possibility of social intercourse between members of the same and kindred professions in a convenient and congenial atmosphere, as well as the possibility of seniors and juniors in the same profession meeting on common ground, and with equal privileges, where both can learn from each other, without the possibility of either the fear of condescension or diffidence interfering with a most natural and desirable exchange of views.

Financing.

Details of the financing of the Institution would, of course, require considerable consideration and cannot be dealt with in detail in a paper of this sort, but, broadly, the running cost of the scheme would be financed on some such lines as the following:—

1. Institutional fees from each participating society's income, rendering their members automatically members of the Institution. These might be preferably on a *per capita* basis, with, possibly, part remittance in the case of members who belong to several societies.

2. Affiliation fees of such additional non-participating societies as may become admitted to membership either in whole or in part.

3. Subscriptions of individuals, either as club members or as library members, of such kindred societies whose members may be eligible for membership, although their societies are not themselves admitted as institutional members.

4. Income from catering department and letting of meeting rooms, etc.

5. Income from endowment funds.

6. Capitation grants from employers of members or subscribers.

The first five of the above suggested sources of revenue do not call for any special reference, but a word as to the last might be advisable.

There can be no question but that an employer of any scientific or technical man does gain in the work given by his employee should the latter keep himself in touch with progress and thought in his own profession, and how can this be better done than by belonging to a society which caters for his special line? Again, under the circumstances of South Africa in general and the Rand in particular, it would be a perfectly fair and a perfectly safe and successful thing to appeal to employers in general (Government, mining, manufacturing and commercial) to support such an Institution as here outlined, and what better basis could they be asked to subscribe upon than by agreeing to pay a yearly subscription on a *per capita* basis for such of their employees as are or become members of one or other of the scientific and technical societies available to help them in their work?

Such employers as agreed—and few, on the Rand at least, would refuse—would therefore become "employer subscribers" and would have their names entered on the annual published lists as such, thereby proving to all their far-sightedness and public spirit.

Methods of Securing Institute.

So far we have dealt with its advantages if and when we get the Institution proposed, and now it is necessary to turn for a time to the possibilities of its eventuating.

There are several ways of securing such an Institution as we desire, namely:—

1. By direct contribution of the societies concerned themselves.

2. By getting some individual or company to put up the money as a business proposition: recovering in the form of rent a fair return on the outlay.

3. By appealing to the general public for subscriptions.

4. By appealing to the generosity and far-sightedness of a wealthy individual.

5. By a combination of any of the above, except No. 2.

Taking these points seriatim we might say as regards:

(1) *Direct contribution of societies themselves.* That desirable and necessary to the success of the scheme, per subscription to the funds on a common basis by each participating society, there would be no hope of securing the Institution if reliance on this source alone were had. The sources of income of societies are too limited.

(2) *Hiring of building.* This basis is the least desirable of all the possible sources and would cripple the societies in their work by the high rent they would be obliged to pay. The combination of philanthropy with business is but rarely successful, and a failure on these lines, as would appear inevitable, would ruin our chances for all time.

(3) *Appeal to the public.* Appeal to the wealthy and business public of Johannesburg and the Reef but rarely fails, and as a consequence they have a very large number of appeals to meet. This source could, however, be much more fairly and successfully appealed to in the direction already indicated, *i.e.*, in the form of annual subscriptions, based on a *per capita* payment for all employee members of societies.

(4) *Appeal to an individual.* This source is at once the most likely and the most reasonable one from which funds could come. It would be an eminently suitable and public-spirited way for anyone who has made or inherited his money from South Africa to show recognition of his good fortune, while at the same time feeling assured that his generosity was going to be both really a blessing to and truly appreciated by a large number of less fortunate people, without in any way introducing a danger of pauperising the recipients.

(5) *A combination of sums raised by the societies and a donation by a wealthy individual.* This would be the best solution of the question, and it is suggested to South Africa's few really rich men that a fair and wise basis would be the promise by one of them of a gift of £10 for each £1 raised by the societies themselves for this purpose, up to, say, a total donation of £100,000 (one hundred thousand pounds).

It may not be generally recognised that there are relatively few really wealthy men connected with South Africa who could afford to give a donation of £100,000 to such an object, but there are a few who could

properly afford it, and it should really only need the placing of such an opportunity in its true light before one or other of these for the chance to be accepted. The opportunity of being remembered by one's name in such an institution as is here proposed does not recur often. If the opportunity were offered in the States, one can imagine but small delay between its being made and its being taken advantage of.

The blanks in the title,

The . . . . . Institution of Technical and Scientific Societies of South Africa,

should form a talisman with which to conjure: fill them up as you think right and make an appeal to the man selected, and it is hard to believe that the Rand would be disappointed.

It must, however, be recognised that a donor as here suggested could correctly lay down his own conditions and that, after discussion and acceptance, it would be up to all the participating societies to make the fullest and greatest success of the great opportunity given.

Probable Cost of Institute.

As regards the cost of the project, it is impossible now to say just how much it would be necessary to have in hand to ensure success. It would, of course, be possible to make almost any reasonable sum supply accommodation to a certain extent, but the true scheme to work for to ensure the permanent success of the project would work out something like the following:—

Estimated Funds Required.

(*a*) Ground varying from £10,000 to £30,000 according to locality, say	£15,000
(*b*) Building, basement, ground floor and four storeys, say	50,000
(*c*) Furnishing, say	5,000
(*d*) Endowment to ensure an income of £2,000 a year to meet assessment, water, light, maintenance, etc., say	40,000
Total required, say ...	£110,000

(*a*) Suitable ground in the neighbourhood of the School of Mines measuring, say, 100 x 150 to 100 x 200 feet would cost, say, £10,000, but if in the best business and social centre the larger figure mentioned above might have to be given. An allowance of, say, £15,000 would be reasonable, and this would admit of the selection of a good and convenient site, even though not in a picked position.

(*b*) A building of about the size mentioned, but which happened to have been built at probably the best time for building in Johannesburg, cost, finished, £41,000 odd. Even if our scheme took a year to mature, and then it took another year to build, we would have to pay higher prices, and it would be wise to allow the full £50,000 mentioned.

(*c*) Furnishing on £5,000 would not allow anything but the plainest and simplest of good South African made furniture.

(*d*) It will be allowed that an endowment of the amount mentioned is little enough to ensure the scheme being entirely self supporting, and we should, on a scheme entailing an outlay of some £70,000, allow fully £40,000 as endowment. With an income of, say, £2,000 per annum from this sum we might have the building and property truly rent and cost free, and could then devote the whole of the income from membership towards the supplying of advantages and facilities for improvement to our members.

Library.

The absolute necessity for a good and useful technical and scientific library in Johannesburg will be allowed by all, and such library, there can be no doubt, could only be adequately and properly housed in such an Institute as here outlined. The Seymour Memorial Library, now in the care of the School of Mines, is, of course, the natural nucleus for such a library, and it would in all probability gravitate to its natural home as soon as accommodation existed: as placed at present, buried away and starved, it supplies but little of the help which its founders and well-wishers expected or would wish it to give.

Action Required by Societies.

If the societies are in earnest on this subject, they should immediately agree on three courses of action, and put them into effect without delay:—

1. To pay in yearly to a trust fund an agreed upon *per capita* sum for each member, the sum so raised to go towards the cost of the joint Institute here suggested. This will prove the societies' *bona-fides*.

2. To agree to loan any capital sums owned by each society to the Institute, at fair interest, to aid in raising the societies' quota of capital.

3. To appoint a joint committee fully representative of all participating societies

to organise the proposition with orders not to desist from its labours until it has brought the matter to a successful issue, even if it should have to appeal, after refusal by South Africans, to a wider field of givers.

It action were taken on broad lines and whole-heartedly by the societies as here suggested, this committee could with confidence approach the right people and ensure that the case for the societies was put before one or more of the few possible people who are in a position to help them; but, unless action is taken whole-heartedly and keenness and sacrifice is shown by the societies themselves, it would not be reasonable to expect assistance in any such project on the part of any person, however public spirited or wishful of doing the right thing.

Previous Joint Action.

It will be within the recollection of members that joint action by societies has been taken on more than one occasion on the Rand, and always with conspicuous success: it is only necessary to refer to the unanimous agreement at the meeting of all societies, called at the instance of the South African Association for the Advancement of Science, on the subject of the desirability of the metric system and decimal coinage; and of another, called at the instance of the South African Institution of Engineers, on the subject of the necessity for the development of industries in South Africa, for members to recognise the advantage of such joint action; a joint meeting of more than one society has also been held, with advantage. It must, however, be remembered that such joint action is the exception and not the rule, and that numerous occasions when joint action would have been advantageous, have been missed owing to the inertia necessary to be overcome before it could be brought about. Any decisions which make such joint action more possible and more weighty in the future are to be encouraged by all possible means.

First Donation.

It will be gratifying to members to know that a personal premise of £100 has already been made towards this object by the President of one of the interested societies, and it is quite probable that more such offers may be made by individual members of societies as soon as it is generally felt that the matter has been seriously taken up and is not to be allowed to lag.

Procedure Proposed.

It is now proposed that this paper and the same set of resolutions shall be read and proposed at a meeting of the members of each participating society, to be held about the same time, so that the motion may be fully discussed by all those interested and the scheme, modified as may appear desirable as the result of such discussion, become the goal and ambition of each society and of each member of each society.

Before it is discussed, however, it would be well to again draw attention to the palpable danger of such a scheme as is here proposed being wrecked on details and non-essentials if discussions are allowed to revolve around these, even though agreement may be general on the main point of closer working and joint housing. If you are agreed on the main principle, let the general joint committee, on which each society will be represented, thrash out the details as far as these are necessary so early in the movement; trust your representatives and give them a general mandate to go forward and not cease their efforts until these are crowned with success.

Participating Societies.

The societies which, in the first instance, are being asked to become participating societies, in addition to the three societies who have taken the lead, namely, South African Institution of Engineers (509 members), Chemical, Metallurgical and Mining Society of South Africa (756 members), and South African Institute of Electrical Engineers (320 members), are the following:—

	Membership
Association of Transvaal Architects	148
Institute of Land Surveyors of the Transvaal	153
S.A. Association of Analytical Chemists	78
Geographical Society of South Africa	146
Geological Society of South Africa ...	121
S.A. Association for the Advancement of Science	819
Astronomical Society	120
S.A. Society of Civil Engineers ...	292
Royal Society of South Africa ...	223
Institution of Mining and Metallurgy (Local Branch)	175
Total membership, including three societies previously mentioned ...	3,860

It is of course probable that other societies may wish to join up and be accepted as soon as the matter becomes generally talked about, but this matter can be left to the future to decide.

The principle which has guided the

committee responsible for the selection of invitations to participating societies is that they shall be either truly technical (in the ordinary application of the word) or truly scientific, and such as can in no way be called a trades union of professional men.

IMPORTANCE OF DEFINITE ACTION.

The recommendation has been made in this paper that each society should at once become responsible for the collection and payment into a common Technical and Scientific Societies Institute Fund a fixed sum annually, preferably on a *per capita* basis, as donation to the Fund, and as an indication of the *bona fides* of their intention to participate in and secure a joint housing scheme, when this can be brought to fruition.

It is of importance that this should be done, as without some such action it would be impossible to prove conclusively to a possible donor that the societies really desired such a joint home and were pledged to its completion.

In collecting the nucleus of such a fund, it would be well to agree that payments towards this be a charge on the members of societies themselves, either as an assessment or by voluntary contributions, and not as the result of canvass of outside persons and firms: this latter source of funds would more correctly be tapped at a later date, and then only as the result of a general campaign on behalf of all the participating societies.

I have pleasure in formally moving the following resolutions:—

Resolved that this Society:—

1. Is desirous of securing in Johannesburg a joint house with such other technical and scientific societies as have an appreciable proportion of their members resident on the Rand.

2. Agrees to pay in an annual sum, either based on a *per capita* or other scale to be agreed, to a Trust Fund, the money so raised to go towards the cost of providing such joint institute.

3. Further undertakes, if legally possible, to loan at interest any capital sums which it is, or may become possessed of from time to time, to such joint institute for its legitimate purposes.

4. Hereby appoints two members with power to act in conjunction with representatives of other participating societies as a joint committee towards the desired end; including appealing for funds, drafting a constitution, fixing the basis of contributions, and, if these are approved by individual societies, securing land and buildings for permanent or temporary quarters and generally to be responsible for the bringing to fruition of the scheme for the joint housing of technical and scientific societies on the Rand.

5. Agrees that the joint committee shall be empowered to receive and deal with suggestions put forward by any of the participating scientific and technical societies through their nominated representatives.

6. Agrees to the inclusion of the following societies, or so many of them as may jointly or severally agree to take part in the scheme as participating societies, namely:

S.A. Institution of Engineers,
Chemical, Metallurgical and Mining Society.
S.A. Institute of Electrical Engineers,
Association of Transvaal Architects.
Institute of Land Surveyors of the Transvaal,
S.A. Association of Analytical Chemists.
Geographical Society of South Africa,
Geological Society of South Africa.
S.A. Association for the Advancement of Science,
Astronomical Society,
S.A. Society of Civil Engineers,
Royal Society of South Africa.
Institution of Mining and Metallurgy (Local Branch).

Appendix 1.—EXTRACT FROM PRESIDENTIAL ADDRESS OF SIR ROBERT HADFIELD TO THE SOCIETY OF BRITISH GAS INDUSTRIES, APRIL, 1918.

NEW BUILDINGS AND LIBRARY, TO MEET THE MODERN REQUIREMENTS OF BRITISH TECHNICAL SOCIETIES.

The writer's presidential work during the last four years in connection with the Faraday Society has brought him in touch with the needs of the many useful societies of smaller nature, and he has been much struck with the serious lack of facilities and convenience for carrying on their work. The societies mentioned below have literally no home or resting-place. A man without a home cannot be expected to accomplish as much as if comfortably housed.

Moreover, this serious drawback exists to a great extent not only as regards the minor societies—that is, minor in membership—but also applies to some of the major societies; for example, the Iron and Steel Institute, with some 2,000 members; the

Institution of Mining and Metallurgy, 2,400 members; the Institute of Metals, nearly 1,000 members; the Institute of Mining Engineers, 2,900 members; the Society of Chemical Industry, 4,700 members; and our own various Gas Institutes and Associations. There are also, amongst others, the Faraday, Physical, Rontgen, Optical, and Illuminating Engineers' Societies. Although the various societies mentioned have offices, these cannot be called "homes," and are totally inadequate to the crying needs of such important organisations. The best use of scientific knowledge and its application to industrial and commercial needs cannot be made unless there also exists the necessary facilities for holding general and committee meetings, with library accommodation and other conveniences.

These conclusions were specially brought home to the writer in the year 1907, when, as president of the Iron and Steel Institute, he attended on its behalf in New York on April 16th, 1907, the opening ceremony of that wonderful structure known as the Engineering Societies Building, Thirty-eighth Street, New York, which is now the chief centre of the great and small technical societies of the great Republic. He was intensely impressed with this important development—one well worthy of America and her progressive policy—and begged in our time of peace that efforts of similar character should be made. It was not, however, found possible to rouse the necessary interest and the opportunity slipped away.

This noble building with all its wonderful conveniences, was made possible in the first instance by the munificence of Mr. Andrew Carnegie, and represents one of the best of his many generous deeds. He vested in a board of trustees, "The Engineering Societies' Building," the magnificent sum of £300,000 upon the condition that the societies concerned, namely, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, also raised a further sum of £100,000 for the building itself, which they did. The building has already been found too small, and has been enlarged by the addition of another floor. The total height is now nearly 300 feet, and there is now also housed in it the American Society of Civil Engineers, which has joined the wise scheme of co-ordination. This important society, whilst not taking part in the original movement, has found that it is greatly to its advantage to do so now in order to obtain the advantages of one common centre for its meetings, reading of papers, and other business. There is also housed in the building the following major and minor societies, some twenty-four in all:—

Major Societies	4	Electrical	4
Minor Societies	3	Gas	2
Engineering, General	3	Electrical & Gas	3
Automobile	1	General	2
Aero	3		

Another important advantage springing out of this technical co-ordination is the fact that one library common to all the societies is made available for scientific and technical literature, now comprising as regards the library no less than 150,000 different books.

Alongside this building, and directly connected with it, is the Engineers' Club, with a large number of members, so that, whether local or from a distance, they are able to find accommodation and meet together in common fellowship—an important side of technical and business life.

It is strange that in this country the technical man has no such home and club—a deficiency which ought to be remedied, and that soon.

To sum up, it must be admitted that unless the technical societies in this country obtain, and that soon, similar accommodation, they cannot in the long run expect to compete in the world's struggle as compared with the admirable centralisation possessed by our American cousins.

It may be mentioned that the German Iron and Steel Institute, the Eisenhuttenleute, is excellently housed in Dusseldorf, also well provided with a splendid library and other accommodation.

Out of such an arrangement as is now outlined for those in this country would spring many advantages, such as better co-ordination of work done, avoiding overlapping of papers or these getting before the wrong society, saving of much valuable time and energy, including the prevention of overlapping as regards times of meetings, and many other advantages. The writer had a recent case in his own experience when he had no less than eight meetings of different societies fixed for the same day between 2.30 and 5 p.m. Even if it had been possible to attend more than two of the meetings, the time lost in reaching the different places would have been a serious bar to getting through the work. With a common meeting-place for our technical societies, as in New York, much of this

overlapping and interference would be avoided.

Will this country rise to the urgent need of the erection of a new building worthy of its great technical societies who have done so much for the Empire? Further, in the scheme should also be included a library adequately equipped with the tens of thousands of volumes and papers now constantly required for reference by those interested in technical development.

Appendix II. — Notes on the American Engineering Societies' Building, from their Handbook.

The Engineering Societies' Building is now the headquarters of the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers—the three national societies known as the Founder Societies—and a score of other kindred engineering and scientific organisations. It is owned jointly by the three Founder Societies, and its erection, and that of the Engineers' Club adjacent, was made possible through the generosity of Mr. Andrew Carnegie, who, in 1903, contributed 1,500,000 dollars for the purpose. The three societies and the club purchased the land on which the respective buildings stand. The Engineering Societies' Building was completed and opened in 1907. It is thirteen and one-half storeys high, has a frontage of 115 feet on 39th Street, New York, and a depth of 90 feet.

On the first floor is the ladies' reception room, a committee room, office of the superintendent of the building and telephone central. The latter contains four booths and the private exchange for the entire building. On the mezzanine floor below the first floor are several dressing booths and lavatories for the convenience of members.

On the second floor is the coat room, arranged on the sectional plan so that several lines of persons may be accommodated at once, and permitting those attending meetings to check hats, coats, umbrellas, packages, etc., and go to the meetings unencumbered. The main auditorium extends up through the third and fourth floors and seats about 1,000. On the fifth floor are two large lecture halls; on the sixth floor, a lecture hall and society offices; on the seventh and eighth floors, the headquarters of associated societies; on the ninth floor, the headquarters of the American Institute of Mining Engineers; on the tenth floor, the headquarters of the American Institute of Electrical Engineers; on the eleventh floor, the headquarters of the American Society of Mechanical Engineers. The twelfth floor is used as a stack room for the library and also contains a small meeting room. The library proper occupies the thirteenth floor.

On the fifth floor are assembly room No 1 seating 500, assembly room No. 2 seating 250, and assembly room No. 3 seating 100. On the sixth floor is assembly room No. 5 seating 150. These rooms are each fitted with a stage and lantern. The lighting system is of the indirect type, the lamps being entirely concealed and the light reflected from the ceiling.

Free Technical Library.

The crowning feature in the plan of the building is the reservation of the twelfth and thirteenth floors for the libraries of the three Founder Societies. The Founder Societies entertain the ambition to create and maintain the finest collection of engineering literature in the world, supplemented by the current periodicals, and the patents relating to inventions in the arts and sciences. There are working alcoves for research accommodation and special provision is made for searches by the library staff, for translating, photographic reproduction, drawing and similar library work. The library contains 65,000 volumes and receives regularly 1,000 periodicals.

The floor below the library proper is devoted to the book stacks. It is fully equipped with steel stacks of the most modern type. One room on this floor is at present reserved for meeting purposes.

Appendix III. — Joint Housing of Metallurgical and Mining Societies.

At a recent meeting of the Iron and Steel Institute, reference was made to the proposal to secure a joint building for the housing of our four great metallurgical and mining societies, namely, the Iron and Steel Institute, Institution of Mining Engineers, Institution of Mining and Metallurgy, and Institute of Metals. At present, three of these Societies have suites of rooms in Westminister, whilst the Institution of Mining and Metallurgy occupies its own premises in the City. A preliminary meeting of representatives of these societies will be held shortly, and, if the main principles of the scheme can be agreed to, definite proposals will be submitted to the Councils

of the respective societies. It is not proposed that the societies should sink their identity in an amalgamation of mining and metallurgical societies, as has been suggested by Prof. Armstrong for the chemical societies of the country; but it is realised that the centralisation of the 8,000 members of the societies in question, under a common roof, with suitable meeting rooms and adequate library accommodation, would be to the advantage of all.

Quite recently the American Society of Civil Engineers has decided to join the other American societies in their building, and three further stories are being added for their accommodation. When completed, the building will house institutions having a combined membership of 26,000, with a library containing 70,000 books and 90,000 pamphlets.

Another instance of the successful housing under one roof of societies having allied interests is to be found in the Chemists' Club, New York, where the American Chemical Society, the American Electrochemical Society, and the New York Section of the Society of Chemical Industry has met for some years past with the happiest results.

(Extracts from Vol. 35, No. 22 (page 1143 *et seq.*) *Journal of the Society of Chemical Industry*, England.)

Appendix IV.—Encouragement of Science in Germany.—German Union of Technical and Scientific Societies.

On March 4th, 1917, at a meeting of the Verein Deutscher Eisenhuttenleute (German Iron and Steel Institute), held at Dusseldorf, Dr. Fr. Springorum said the war had intensified the need for closer co-operation of the German technical societies. Preliminary negotiations had therefore led to a combination of such societies, and the Verein Deutscher Eisenhuttenleute had gladly joined such Union and promised their support.

On April 19th, in an article published in a German newspaper, it was stated that the managing committee of the Union had decided to create an intermediary agency between the technical world and scientific institutions for the carrying out of scientific and technical research work, so that industry not equipped for experimental work, especially smaller concerns, might be afforded an opportunity of having problems solved through the aid of the Union.

In November, the Union held its first general meeting at the premises of the Association of German Engineers, at which the Imperial Government offices, Federal Council and legislative bodies were represented. The purposes and aims of the Union were explained. It was stated their object was to establish a balance between science and practice, and that the technical world ought to be represented more than was hitherto the case in the legislative bodies.

The managing committee of the German Union of Technical-scientific Associations has decided to create, at its offices, a department which is to act as an intermediary between the technical world and the scientific institutions of the Universities and the technical academies for the carrying out of scientific-technical research work.

The German Union and the heads of the scientific institutions hope that this agency will be of value and prove very useful not only for the duration of the war, but also in the subsequent economic life of peace-time.

The German Union of Technical-scientific Societies, which has recently been formed by the combining of thirteen associations and unions, held its first general meeting on the premises of the Association of German Engineers in Sommerstrasse, where the chairman said that their object was to establish a balance between science and practice. Many a technical task could not be carried through without participation and collaboration of several branches of science; the metallurgist required the co-operation of the technician, the architect that of the engineer, etc. An influence was also to be exerted on technical instruction and education, and towards ensuring that the academically-trained technician should be admitted to all administrative departments of the Federal states. The technical world ought to be represented, more than was hitherto the case, in the legislative bodies. The Union had also applied to the authorities with a view to being consulted in the preparatory work of drafting regulations or enactments. Unfortunately, hitherto, the Imperial Treasury alone had availed itself of their advice, in the preparatory work for the taxation of coal and sources of energy. Finally, the speaker stated that a desire had been expressed that an Austrian and Hungarian section should be attached to the Union, as to which resolutions were still to be passed.

(Extracts from Bulletin of the American Institute of Mining Engineers—August, 1918, page LI., *et seq.*)

I would suggest that we do not now move these resolutions which I have read or vote on them to-night, because obviously members would wish to read this paper in the *Journal*, which will appear before the next meeting; but that rather you take the discussion and those resolutions at the next meeting. Also, if you wish, I would be quite prepared to introduce the discussion at the next meeting, giving the reasons for many of these recommendations which obviously you could not insert in a paper such as this (it is long enough now as it is), but there will be many explanations that members will wish, and be entitled to, which can best be done in the course of discussion.

The President: I personally am fortunate enough to be a member of the Sub-Committee which is responsible for assisting Mr. Cazalet in a very small degree in compiling his paper. Therefore, my modesty does not permit me to praise it to the extent that my natural inclination and good sense would prompt. This subject, as you know, has been mooted for a number of years, and here this evening we are fortunate enough to be the first of the Societies to have the matter placed before it in a concrete form. Your Council has gone very closely into the matter, and attended the joint meeting that took place a short time ago, pledged itself, on behalf of your Society, to further this movement. As Mr. Cazalet has suggested now, I do not think this is the occasion to formally move and pass, or otherwise, the resolutions, because the membership as a whole has not had the opportunity of fully going into the matter; but the paper will be printed in our next *Journal*, and will be open for discussion at the next meeting, as a matter of fact, it is at the moment.

There is one feature of it that perhaps Mr. Cazalet did not mention, and that is, that if we should be fortunate enough to bring such a scheme to fruition, the strengthening of the membership would be enormous. Any societies that could offer advantages of such a description would be able to pick and choose, I think, their membership.

I will leave the matter, as far as I am concerned, at this stage and ask any of those present here to-night if they have any comments or suggestions to make on behalf of the Society, or their own personal views, or any questions. Mr. Cazalet has been good enough to come here to-night and will answer any questions that are asked, and he has also been kind enough to say he will be present at the next meeting to carry out the same policy.

Mr. P. Cazalet: I might perhaps add to what I have said, that obviously the whole thing hangs on the possibility of getting the money. Two sources are suggested, which, of course, are not final, as these would have to be decided by the Joint Committee to be nominated, including your two members. The one source is the Societies participating themselves—that is, from the members of those Societies, and the second from a donor or donors. Now, you may very reasonably say: "What are the chances of our getting any money from a donor or donors?" I cannot tell you that; nobody can; but I can tell you that if you do not ask you are never likely to get it; but, if you ask, you may! There are several people who could influence such donors, and, I may add, that to my own knowledge there are only two or three connected with South Africa who could possibly afford such a thing as is here suggested. Those people who have been spoken to about it say: "If you have a good case, make it out, and put it before the right people, and at least give them the opportunity of considering it." I think that is about as good a lead as we can hope to get; and that however far-fetched the idea of getting money from such persons may appear it ought not to weigh with us in our decision as to making the attempt, because I do feel this, that if we fail with the few South African people who might be able to afford it, there is no reason in the least why we should not go further; and I think the mere fact that it is known we could and should go further and, say, apply to Mr. Carnegie or other far-sighted philantrophists, who see the advantages of this kind of movement, would make it very difficult indeed for the few people who can put down this money to refuse when they have the opportunity put before them in the proper way; and it is obviously the first business of this Joint Committee to make their case in such a form that it can be laid before these people, and so give them an opportunity of saying "yes" or "no."

Now, there is one other point that the President has referred to, and, of course, it is so obvious that it does not appear in the paper; that is, as soon as you give

members a really attractive ownership, or really attractive conditions, such as no single society can offer to-day, your membership is going to increase enormously, and your strength is going to increase enormously, jointly with other societies; my view is that the mere fact of such privileges as are proposed in this scheme being laid before the average man who is not a member of any technical society, will make it impossible for him not to join some society which can help him, and the effect will be to improve his status, and that of the societies. Also, I think, we must recognise this, that any society which deliberately sets out to remain aloof from such a scheme as this will be very sorry, if it is a success, because obviously they can subsequently only come in on the terms which the participating societies will be prepared to lay down; that is to say, it is to the interests of all societies to enter at first, and make a real attempt at the scheme which is proposed, provided, of course, they feel that it is not too far drawn and impossible of success.

Mr. J. Gray *(Vice-President)*: I think we all recognise that the moving spirit behind the scheme is Mr. Cazalet, and I am sure we are greatly indebted to him for coming here this evening and placing the scheme before us. We recognise our obligations to the other members of the Committee, and I think, if they have the same enthusiasm as Mr. Cazalet has shown, that in the not far distant future we will have our home.

One matter I would like to refer to, as your representative on the Seymour Memorial Library Committee, is with regard to the housing of that library in the future home of the technical societies. It has probably been noticed that a list of missing books has been published in the last two agendas. I have always strongly objected to the books being taken away from the library as I consider that the Seymour Memorial Library should be a reference library: under present conditions it is not such, and, judging by the number of books which have disappeared from the shelves during the last few years, I think that the sooner there is some sort of home for the Seymour Memorial Library the better it will be for those who desire to use it as a reference library.

I have much pleasure in proposing a vote of thanks to Mr. Cazalet.

Mr. T. G. Martyn *(Member)*: If I may have the privilege of seconding that vote of thanks, I think that such a union of our Societies, or rather the joint housing of our Societies, would certainly be very advantageous indeed. Just to mention a personal matter that would never have occurred if we had had such joint housing in the past. When I first came out here I joined this Society as a matter of course, and as it is the Chemical, Metallurgical and Mining Society of South Africa, I naturally supposed that I should here meet everyone who is interested in mining engineering and everything of the kind. After a bit, I was rather surprised to find that some of the leaders of our industry, *e.g.*, our consulting engineers — were conspicuous by their absence. Afterwards, I found there was another Society to which these consulting engineers devoted most of their interest, and, no doubt, some of us would have benefited very greatly if we could have had the opportunity of hearing their views on the papers read at the other Society's meetings, many of which would be equally interesting to our own members. Now, such a thing as I have mentioned could not happen if all the Societies were housed together; a newcomer would know there are two, three, or four Societies, and would have a chance of joining perhaps a couple of them if he wished to do so, and of meeting the leaders of industry in a friendly sort of way, where he might discuss things with them, as Mr. Cazalet has said, without feeling that they were condescending towards him, or anything of that kind; he might meet everyone connected with the industry, and so have a wider view of things than has been possible up to the present.

Mr. H. A. White *(Vice-President)*: I should just like briefly to associate myself with the cordial approbation with which the paper we have heard this evening has been met. One of the reasons in the past which has prevented our Society from giving all the asistance to this movement which it might have been able to do was some fear of sinking its individuality. I think that that no longer is a live motive; I think we are all agreed that we can still maintain our individuality while working in closer co-operation with kindred societies as well as we could if we remained aloof; and I think that the advantages to be gained by closer working do not entail deprivation of freedom, but that they do involve a great

increase of strength. I think that is the tendency all over the world at the present time. You will find that unions are arising and, in many cases, small unions are arising, which could do much better for themselves and much better for their members if they associated themselves with larger organisations.

I should just like briefly to remark about the Seymour Memorial Library that I have been associated with it for some time past, although I am not at the present time your representative member for it; I think it was on my initiative that this method of lending out books, to which Mr. Gray objects, was adopted. I do not believe in that institution being made a tomb, and that is what it got into the way of being. Those books are of some use on the shelves there, but they are of much more use in the hands of readers. If those readers cannot spare the time to come and read there —well, if the mountain cannot go to Mahomet, Mahomet must go to the mountain.

The President: And he must bring the books back!

Mr. H. Rose Martin *(Member):* As a member who has resided in the country for some time, I should like to mention, from the country members' point of view, not only of this Society but of others, that I think that in the country especially it would be greatly appreciated, especially from the social side.

NOTES ON DEFECTIVE AIR IN DISUSED RAISES AND BACKSTOPES.

By C. J. Gray (Member of Council).

It is common knowledge that owing to possible accumulation of carbon dioxide gas, precaution should be taken when entering disused winzes. It is however, not generally realised that apart from possible occurrence of fire-damp similar precaution is advisable in disused raises and similar places in Witwatersrand mines.

My attention was drawn to the danger by an occurrence at the Wolhuter Gold Mine where, on 14th January, 1918, the dead body of a native was found about 65 ft. up a raise. He had been missing since 8th January, and was supposed to have deserted. It is surmised that he went up the raise to hide and escape work.

The raise had not been worked within the preceding six months. It went up 184 ft. at an inclination of 31°, and was about 4 ft. wide and 4 ft. high. It was on the South reef, and had no connection above the drive from which it started. It had been put up by a hammer drill.

When it was decided to search the raise it was found, according to the mine overseer, that about 15 or 20 ft. up, the flame of an acetylene lamp fluctuated, becoming dull and low, then "fissing" up and then again becoming low. An attempt to light a candle failed as matches flared and went out. A compressed air hose was then taken up, and after three further attempts the dead body was found. It was face downwards with head up the raise and arms and legs partly extended. A candle with about 1 in. burnt was found at the place. The mine overseer felt headache, weakness and giddiness, as a result of his experience, but the shift boss who was with him felt no ill effects except smarting of the eyes.

I visited the raise next day. Though it had been blown out sufficiently to allow of the body being removed the day before, the air in it was not normal. Using Haldane's tube for flame test for black-damp, I found the reading 0·5% outside the mouth of the raise, and that going up the raise the black-damp percentage increased gradually to four and then, where the body had been, sharply to six. A few feet further up a candle just burnt when still, but went out when moved. I did not consider it advisable to go further.

A sample of air taken where the body was found gave, on analysis by Dr. James Moir, 16·4% oxygen and 0·60% CO_2.

After leaving the raise I had a slight headache with a feeling as though the crown of my head tended to lift, but it passed away very quickly. On my way back to the shaft I became distinctly conscious of my ear drums though they hardly could be said to ache, but that feeling also went after a few minutes.

The cause of death of the native was not discovered in the post mortem examination owing to decomposition of the body being advanced.

On the 24th January, ten days after the body was found, I again visited the mine. In order to ascertain whether defective air

was peculiar to the scene of the death I first inspected a similar raise in its vicinity but in the Main Reef Leader. That raise had been out of use for about six months.

Using Haldane's tube I obtained the following successive readings:—

	Black Damp. Per Cent.
(a) In the level at entrance to raise	1·0
(b) About 20 ft. up	1·75
(c) About 42 ft. up	2·5
(d)	2·75
(e) On a fault 75 ft. up	4·75
(f)	8·5
(g) 10 ft. from the end of the raise	10·0
(h) At the end of the raise 135 ft. up from level	19·5

The raise is on a fault from (e) to (g). Careful tests with the taper along the joint failed to give any sign of issue of gas. In some small pockets in the roof near (f) however, the taper was extinguished, but those pockets which were due to irregularity in the breaking of the stone, showed no cracks in the quartzite. Perhaps products of combustion from the tapers helped to extinguish it. Near the end of the raise I found that, apart from those pockets, the taper burned most brightly when held near the roof or near the floor, and was dullest and most easily extinguished by motion when well away from either.

A sample of air taken at the end of the raise on analysis by Dr. Moir gave: oxygen 17·6 and CO_2 trace (about 0·2), but it was remarked that "the stopper of the sample was not quite tight and no pressure was present when opened." Dr. Moir found that a taper burnt fairly well in the sample with about half light.

After leaving the Main Reef Leader raise I visited the South Reef raise in which the death had occurred, and was able to get up 15 or 20 ft. above where the body was found, before my candle was extinguished. There the candle would burn near the roof or floor but not in the centre of the raise. A sample of air was taken about 92 ft. up the raise by drawing it by an exhaust pump through a tube attached to a pole. After that sample had been taken it was found impossible to light candles near the pump probably because of the bad air which it had drawn down. They did not give any sign of lighting even when the wick was held in an acetylene lamp flame. As in my previous experience I got a headache and a few minutes after leaving the raise, a feeling of consciousness of my ear drums, but those symptoms were transient and had gone by the time I reached the surface. The sample taken was found by Dr. Moir to contain oxygen 14·35 , and CO_2 0·55 and to extinguish a taper.

On 8th February, 1918, I made somewhat similar investigations in two disused back or overhand stopes without through ventilation in the Nourse mine.

In stope 20-2 W. South reef I got with Haldane's tube:—

	Per cent.
Black-damp in level	0
,, 20 ft. up stope ...	1½
,, 60 ft. up stope ...	2½

Readings of 2½ continued to the top of the stope between 100 and 120 ft. above the level.

In stope 20-3 W. South reef, my observations were:—

	Per cent.
Black-damp in level .	0
,, 20 ft. up stope ...	1
,, 60 ft. up stope ...	3
,, 80 ft. up, at bottom of raise	7
,, 95 ft. up, in raise ..	7

Mr. Beaton, the manager, scrambled on to the top of the raise, 140 ft. above the level, and got a reading of 6 at the top.

A death under circumstances similar to the Wolhuter case occurred in May, 1917, in the Knights Deep G.M. In that case the dead body of a missing native could not be recovered from a small disused backstope only 50 ft. above the level, till compressed air pipes had been installed and used.

Mr. E. S. Watson, Assistant Inspector of Mines, who visited the place eighteen days after the body was removed, found that both a candle and an acetylene lamp were extinguished when near the roof of the stope, the gas hugging the hanging wall. A sample of the gas taken through a long tube by Mr. C. E. Hutton, Inspector of Mines, in July, 1917, when the stope had stood some time after blowing out, gave on analysis by Dr. Moir. Oxygen 13·1 , CO_2 0·55 , insoluble 86·35 . The insoluble gas was found to contract by 0·18 on passing over a hot wire, and to contain therefore 0·12 hydrogen or 0·06 methane.

From the foregoing it may fairly be concluded that frequently, if not always, the percentage of oxygen in disused raises and backstopes falls below that in normal air, and that occasionally it becomes so low that lights will not burn and, in extreme cases, that persons cannot live in those places.

The percentages of carbon dioxide shown by the analyses are too low for air partially deoxidised by breathing or by lamps or candles, and too high for air deoxidised by the decomposition of iron sulphides. Possibly nitrogen issues from the rock as it has occasionally been found to do in other parts of the world. The Knights Deep case looks as though it would fit in with that idea as the gas soon accumulated after blowing out, and was not well diffused, and as there was a dike at the top of the stope.

On the other hand, my Wolhuter and Nourse observations though not conclusive are decidedly against that explanation. Another possibility is that decomposing pyrite or pyrrhotite has not only had deoxidising effect but, by action of the acid formed, has produced carbon dioxide from carbonates in the rock, or perhaps indirectly from lime in water used for phthisis prevention when work was in progress, but there again I find the possible explanation not quite satisfactory. As there was no visible sign of pyrite decomposition in the Wolhuter raises, it is hard to believe that it was going on at a rate sufficient to so outweigh the tendency of air to circulate and gases to diffuse, that the oxygen percentages fell as low as they did. I must therefore leave the cause of the phenomenon an open question, which some other member of the Society may perhaps have the opportunity of settling.

Before concluding, I wish to make some reference to Haldane's tube or flame test apparatus, which is not nearly so well known on the Rand as it should be. Essentially it is nothing more than a piece of glass tubing in which a taper is burnt. The flame of the taper produces an upward draught, which is stronger the lower the taper is held in the tube, and which tends to blow out the flame. The more deficient in oxygen the air is, the weaker the draught which the flame will stand, and the higher up the tube the taper must be held to keep it alight.

In use, the tube is held vertically, a lighted taper is pushed well up, and then brought down gradually and the graduation on the tube at which the light goes out is noted.

Those graduations are for percentages of black-damp which Dr. Haldane defines as "the residual gas resulting from various oxidation processes in mines and the surrounding strata," and which "as ordinarily met with is simply nitrogen mixed with from 5 to 20% of carbon dioxide." If the oxygen percentage in air were reduced to 20·07 from the percentage, 20·93, in pure air, the percentage of black damp would be $100\left(1-\frac{20{\cdot}07}{20{\cdot}93}\right)=4{\cdot}11$.

Haldane's tube has been graduated with black damp, produced either by respiration or by allowing gas to burn in a chamber, in an atmosphere saturated with moisture at about 64° F., and presumably at slight elevation above sea level. Those are not the conditions in Witwatersrand mines, but I have found that at a depth of 2,000 or 3,000 ft. in down-cast air the taper goes out at the zero mark, and that in comparative tests made under usual conditions in the mines, if the black-damp percentage according to the tube is divided by five, as was, I believe, first suggested by Dr. Moir, a close approximation to the carbon dioxide percentage determined by analysis is obtained.

The only analysis in this note which is comparable with a Haldane tube observation is that of the sample taken at the top of the Wolhuter Main Reef Leader raise, the analysis giving oxygen percentage 17·6, and the tube black-damp 10·5. Calculating from the oxygen percentage black-damp should be 15·8%.

The inconsistency is probably due to the air in the raise not being ordinary residual air partially deoxidised by combustion or breathing. That such is the explanation may be deduced from comparison of the analyst's statement that a taper burnt fairly well in the sample with Dr. Haldane's statements that a taper when held upright will no longer burn outside the tube with less than 18·2% of oxygen or 13% of black-damp, or when horizontal with less than 17·2% oxygen or 18% black damp, and that both moisture and carbon dioxide have a somewhat greater effect in extinguishing flame or diminishing the light than a corresponding percentage of nitrogen has. Though under the particular circumstances the tube probably did not give a correct result, it certainly gave very valuable information with regard to the deterioration of the air as the raise was ascended. Apart from its convenience in use it gives information which goes beyond that given by the carbon dioxide determination systematically made on the Witwatersrand. In considering the adequacy or otherwise of ventilation to avoid

impairment of health and energy, we require to know whether or not sufficient oxygen is supplied to the men, and the tube shows whether or not there is deficiency in that respect.

Though the observations given in this note refer only to disused workings, it can be deduced from them, especially if the cause of deoxidation is pyrite, that the air may be seriously, though less obviously, defective in some places in which work is in progress. The observations therefore emphasise the need that mine officials be not content with carbon dioxide analyses and dust determinations, and satisfy themselves that the oxygen supply is everywhere sufficient.

Dr. L. G. Irvine *(Member):* I wish to congratulate the author on his having been the first to give detailed proof in this Society of the fact that "black damp" does exist on the Witwatersrand, and may in exceptional circumstances be a source of danger. In 1915 I called attention to the same fact myself in a paper on "Accidents from Poisonous or Asphyxiating Gases in Mines," read before the local branch of the British Medical Association. I may quote here the account of an accident which happened in 1913, and which I concluded then could be due to no other cause than black damp. Like the accident which Mr. Gray has described, it happened in a disused back stope. I have always taken a great deal of interest in gassing accidents on the Rand, and by the courtesy of the Government Mining Engineer I was able to go through the reports of all the fatal gassing accidents which had occurred over a period of six or seven years. I found that all of them were due to the fumes of explosives and, in each case, were due *predominantly* either to carbon monoxide or to nitrous fumes. But I always realised the probability that in cases occurring down winzes there was a certain amount of deficiency of oxygen; and that the presence of carbon dioxide derived from the fumes of explosives also co-operated with the carbon monoxide in producing symptoms. But I never found any case where black damp in itself could be regarded as the cause of death, until later on amongst the reports I read the following case which occurred in 1913. It is very interesting, and I think Mr. Gray may be interested to hear it. This account of the accident is taken from the paper I referred to:—

Poisoning by Black Damp.

"5.6.13.—A native wishing to shirk his work ran up a raise. A little stoping had been done from the raise some considerable time before, but since then the place had lain entirely idle, and the inspector stated that fumes from blasting in neighbouring workings did not pass the foot of the raise. The place was roughly in the shape of an inverted bottle, some 50 ft. in vertical height.

"The native was seen at 9 a.m. and missed at 10 a.m. Another native then went up after him for 20 or 30 ft., but his lamp was extinguished. He came down and recharged it, but on his going up again it was once more extinguished. He went back and called a white miner, who went up the raise with the native, taking his acetylene lamp. This also went out. He sent the native for a lighting stick, and they returned with another miner. The latter's acetylene lamp was also extinguished.

"The first miner reached the boy, and endeavoured to pull him out, but was himself overcome by the gas. He made another attempt to reach him, but became unconscious, and was carried out to the station, where he revived. A shift boss with fresh boys then went up, about 12.15. They reached the native, who was dead, and brought him out.

"This is not the account of an ordinary gassing accident. No blasting had recently taken place in the raise, nor was the place exposed to vitiation from this cause. There are two important points to be noted. First, acetylene lamps were repeatedly extinguished. The flame of a candle or oil lamp will be at once extinguished if the oxygen percentage falls to 16%, and at a rather higher point, say, 17.5%, more or less, if carbon dioxide is present also. But the flame of an acetylene lamp is much more 'tenacious,' and is not extinguished until the oxygen percentage has fallen to about 10. Secondly, the white miner attempting rescue was rendered unconscious *almost immediately*, and the native died within a short (but undefined) time.

"These facts point to the conclusion that oxygen deficiency was the factor which produced the fatal results. The presence of a large amount of black damp in this unventilated bottle-shaped working is the only explanation which reasonably fits the circumstances. Probably the black damp contained little or no carbon dioxide. Dr. James Moir informs me that carbonates are of rare occurrence in the mines of the Rand, and that any black damp formed would commonly be due to the oxidation of pyrites (particularly pyrrhotite), and would consist practically of pure nitrogen. It would therefore be lighter than air.

"Such an occurrence is, however, exceptional, although it certainly suggests that, in 'gassing' accidents from the fumes of explosives, some amount of black damp may sometimes be present also, when the working has lain idle for more than the usual periods."

I particularly congratulate the author on being the first to give us *analyses* of the air in those places; that is a valuable contribution to the subject, which has not before been done. I observe that the amounts of carbon dioxide present in the air in these places are small, and I fancy that Dr. James Moir's idea is correct, namely, that the

black damp formed was practically pure nitrogen, and that the diminution of oxygen percentage was due to the absorption of oxygen by oxidation of pyrite. Consequently there was much more nitrogen in the air than normal which is always the case in black damp, of which by far the larger part always consists of nitrogen. It was not a case of carbon dioxide poisoning at all, but of asphyxia from oxygen deficiency, which poisoning by black damp usually is. Even in coal mines the cause of death from black damp poisoning is almost invariably oxygen deficiency. It is very rarely that there is sufficient CO_2 in black damp in a coal mine to be the cause of death. CO_2, if present in fair amounts (say, 3—6%) produces symptoms of breathlessness and panting, which give warning of bad air; but CO_2 is very rarely in itself the cause of death. How far Dr. Moir's idea regarding the oxidation of pyrite is a complete explanation I do not know. That is a question for further analysis of the whole circumstances of the case. But it is interesting that in one of the author's cases in which the flame was extinguished the bad air hugged the hanging. This would suggest that it was practically pure nitrogen which, of course, is lighter than air.

I am glad to have had this confirmation of my view that black damp may be present in unventilated workings on the Rand, which, as I say, I suggested in 1915. The symptoms from which those who went into the bad air suffered were those of simple oxygen deficiency. Oxygen deficiency, if a man is not exerting himself, does not produce marked effects until it falls to about 10%. The oxygen is 20·9% in normal air. When it falls to about 12 or 10%, it produces definite symptoms. It produces unconsciousness at about 7 or 8%; anything below that may be fatal.

There have been cases where adulteration of the air by fire damp, quite apart from black damp, has produced a sufficient degree of oxygen deficiency to be fatal; although "methane" is non-poisonous and simply acts as an adulterant of the normal air. There was one case in England where two men were rescued alive but unconscious by the use of oxygen breathing appliances. They had been in an atmosphere heavily vitiated by fire damp. I think myself that the cause of the whole trouble referred to was the oxygen deficiency in the air.

Mr. H. A. White *(Vice-President):* I should just like briefly to remark that pyrrhotite is somewhat scarce in our mines, and the oxidation of pyrite alone would probably be sufficient to cause this deficiency of oxygen which has been referred to under the somewhat unscientific term of "black damp." I do not think black damp is a word that should be used in gatherings of this nature if it can possibly be avoided; it is like "mullock" and "muck" terms which we usually throw out of our proceedings.

Dr. L. G. Irvine: It has a very definite meaning.

Mr. H. A. White: Yes; it includes deficiency in oxygen, excessive nitrogen, and is sometimes used as a synonym for carbon dioxide. It is somewhat vague. In a winze 8 ft. × 6 ft. and 100 ft. deep, 200 lb., of FeS_2 could remove the oxygen present, and a layer of one-sixth of an inch of rock on the walls would contain about that amount. I should like to mention also the possibility that though this deficiency in oxygen was caused by absorption during decomposition of iron pyrite, there is also a possibility that there might be traces of sulphuretted hydrogen present, and I think something of that nature might be called upon to explain the rapidity of the death in the one case mentioned by Dr. Irvine.

Dr. L. G. Irvine: The smell of sulphuretted hydrogen is quite distinctive.

Mr. T. G. Martyn *(Member):* I think the poisonous character of sulphuretted hydrogen is somewhat over-rated, because one gets accustomed to smelling it with apparently no evil effects at all. I feel quite sure it would take a very heavy dose to poison anyone; but I was very much surprised to hear Dr. Irvine when speaking of the deficiency of oxygen, say that the amount of oxygen might fall to 10% before becoming dangerous. My recollection of papers I have read on the subject is that when one gets down to about 17% it begins to be dangerous, and when it gets down to 15% or 14%, one is likely to be killed by it. That is, I think, my recollection of papers Dr. Haldane wrote on the subject. There is a possibility in my mind that the gases from blasting might contain a good deal of nitric oxide (N_2O_2).

Dr. L. G. Irvine: They do.

Mr. T. G. Martyn: Well, if that is the case, this gas would greedily absorb

oxygen, and might easily be the cause of the deficiency. I quite agree with Mr. White's remark about "black damp" being rather a vague term to use here. It is so customary, I suppose, in colliery districts, that it has almost become classical; but it certainly conveys no meaning to us who are not acquainted with colliery work, and if we could speak of oxygen deficiency I think it would be a better term to use than percentage of black damp. I was wondering what it could be (of course it was explained afterwards) to have 7% to 9% of it in the air, and thought it might be marsh gas; carbon monoxide would be too deadly and carbon dioxide improbable with so much water about.

Dr. L. G. Irvine: Might I say that the meaning of black damp is perfectly settled and perfectly well understood. It is the residual state of the atmosphere in the unventilated portion of a mine, or in a well, or in any deep cutting, resulting from the processes of oxidation which go on when air penetrates underground. By far the larger part of black damp always consists of nitrogen. The amount of CO_2 may vary from 0% to 20% according to circumstances and unless the amount of CO_2 reaches 6% or over black damp is not heavier than air. It has been found in coal mines that, when the oxidation is mainly that of coal very little CO_2 is present in the resulting black damp, but where the oxidation is mainly that of timber, the proportion of CO_2 in the black damp is greatly increased. Here, however, we have to deal with the ore bodies of the Reef, and we have got to consider what are the oxidisable substances in these which are going to withdraw oxygen from the air, and what will be the resulting condition of the atmosphere which remains. Black damp has nothing to do with fire damp at all. But there is one common feature about both, namely, that it they are present in sufficient amount to reduce the oxygen to a certain point, they will produce the same danger of asphyxia from that cause. The last speaker is quite wrong in thinking that oxygen deficiency is dangerous at so high a level as he mentioned, namely, 17% or 16%. Air which will just extinguish an open light may be perfectly safe to breathe: that is the trouble about it: miners know that. If when a light went out miners knew they were going to be asphyxiated they would get out; but they know that in many atmospheres in which a candle or oil lamp is extinguished it is perfectly safe to proceed and it may be so. The trouble is that while the extinction of lights gives warning of tainted air, it gives no measure of the *amount* of vitiation, and that is why small animals, such as canaries and mice, are used, because their use does give a measure of the danger. They are affected sooner than human beings, and so their disablement gives warning for men to withdraw. The extinction of an acetylene lamp, however, is an *urgent* danger signal since a degree of oxygen deficiency which will extinguish an acetylene flame will produce effects on men.

I hope the author, if I may say so, will continue his investigations of the black damp formed in these disused workings, because I think it is a most valuable piece of work.

The general conclusions to be drawn are, I think:—

(1) That the amount of black damp formed in the mines of the Rand is *in general* not of practical importance.

(2) That in disused close workings, *especially* in raises and in back stopes black damp does form, and if they are left long idle it may accumulate in dangerous amounts, as these fatalities show.

(3) That the black damp so formed appears to be a "light" black damp (*i.e.*, lighter than air) being composed of nitrogen with very little CO_2 and so it tends to remain in such workings as raises and back stopes until dispelled by ventilation.

(4) Such cases obviously show the necessity of thoroughly ventilating any close workings especially if disused for some time, before they are entered, and of securely closing off all such workings into which it is not necessary to enter.

Mr. J. Allan Woodburn (*Associate*): I was particularly struck with the opening remarks of Mr. Gray, when he referred to winzes being known to be sometimes rather defective, because black damp or CO_2 was likely to occur there, CO_2 being heavier than air, and therefore likely to be found in winzes not properly ventilated, and the inference was that it was rather an unusual thing to find similar defective air in raises. The conclusion that this was due to CO_2 seemed strange. I think Dr. Irvine's remarks, coupled with the analysis given in the paper, fully explains that the CO_2 was not sufficiently great to speak of the danger as being due to CO_2, and the deficiency in oxygen and the increase in nitrogen would naturally make the air, as a whole, lighter and so tend to accumulate in raises.

Dr. L. G. Irvine: To remain there?

Mr. J. A. Woodburn: Yes, and not only to remain there, but to gravitate upwards, if one may speak of gravitation upwards. In coal mines, marsh gas or fire damp tends to accumulate in any holes in the roof or in any raises that are not open to the level above, even although the gas may come from other portions of the mine.

Now, in any drive, if oxygen is being taken from the atmosphere by any means so that any portion of the air becomes lighter than the previous air that was going in, it will naturally tend to accumulate in any bottle-shaped raise, because, being lighter, it will tend towards any opening in the roof. So that this atmosphere reduced in oxygen might easily come through drives at a lower level and gradually accumulate without any oxidation of the pyrite in the reef. It seems to me the whole point is this, that ventilation should be in every working place or in every place where men or boys congregate underground, and the same precautions should be taken in gold mines, to have some form of ventilation, even a little, in the same way as in coal mines, in order to take away the gases which are formed there.

The President: Mr. Gray's paper and the discussion have been extremely interesting, and it seems to me to lead to just one practical outcome, and that is this, that it is manifestly impossible for a mine to carry a complete system of ventilation through disused workings: there is no sense in doing it, that I can see; but, at the same time, if such dangers exist as the author points out, it is quite clear that barricading of disused workings would be a great aid to safety underground. I do not put that forward as a suggestion to the Inspector of Mines, because he might go and add it to the regulations, nevertheless it is well worth the consideration of miners.

A "SAFETY FIRST" METHOD FOR THE ESTIMATION OF CO_2 IN MINE AIR.

By H. R. S. Wilkes (Member).

Prof. Neve Foster more than thirty years ago suggested the use of a saturated solution of lime in water as a guide in mine ventilation, but the varying solubility of lime at different temperatures renders anything like a close estimation by its means a matter of difficulty.

With the method under consideration, percentages which approximate to the safety limit set by Government can be estimated to the third place of decimals. Higher values than 0·30 can also readily be estimated with a little extra care, but as these are really only of statistical value it is unnecessary to consider them in dealing with a method which lays claim to the title of "Safety First." This claim has been made for the reason, that by its general and regular use in mines the safety of underground workers can be guaranteed from the dangers resultant on working in an atmosphere containing high percentages of CO_2. Incidentally it offers protection to underground officials responsible for ventilation, from unprofitable and vexatious encounters with the majesty of the law.

With the "Safety First" method:

The estimations are conducted, and results obtained at the place of sampling. No technical knowledge or special skill is required of the person actually making the estimation. The results are obtained in from five to ten minutes. All calculations and reagent preparations are made in the laboratory before being placed in the hands of the sampler. The outfit weighs less than 20 lb. when fully charged, it is quite inexpensive, and can be made in the mine workshops.

It is not suggested that the "Safety First" method should depose the standard one at present in use, rather may it be considered as an extension of that method, making possible the examination of a much greater number of samples and so giving increased knowledge of the air conditions of the mine. The statistical records being made by the standard method they will afford periodical checks on the "Safety First" results, if the estimations are made at the same time and place, by both systems.

The "Safety First" method is based on the standard one except that quantities used are tenths, and the operation of titration with oxalic acid is eliminated.

The baryta water is of deci-normal strength, and the reduction to N.T.P.,

allowance for water vapour tension, etc., are all calculated, and then regulated by the amount of the reagent used. The indicator used is phenolphthalein. The water used in making up the baryta water and in diluting the reagent must be freshly boiled distilled water.

The reagent phials should be ground glass stoppered, though owing to the difficulty of obtaining such, rubber corks have so far been used.

7. One foot rubber tubing, ½ in.
8. Table of values corrected for varying depths.

Directions for Testing.

On arrival at the sampling place one of the 8 oz. bottles is filled with air by the aid of the bellows, the sampler using precisely the same precautions as with the standard method except that the bottle does not need corking, and a few strokes of the bellows only are needed. A reagent bottle is then taken (the strength selected according to the judgment of the sampler), and after uncorking, is immediately connected with the sample bottle by means of the transferer. The holder is then adjusted to prevent all leakage, and the reagent bottle inverted and shaken to transfer the baryta water to the sample bottle. The shaking is continued for from one to seven minutes, that is until the pink colour is discharged or remains unchanged after seven minutes, which is long enough.

Table of Corrected Values of Testing Phials for Percentage of CO_2 at Varying Depths.

Height above Sea Level. Feet.	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
+6000	·150	·200	·250	·300	·350	·400	·450	·500	·550	·600	·650	·700
5500	·146	·196	·245	·291	·342	·393	·442	·491	·539	·588	·637	·687
5000	·143	·193	·241	·286	·337	·387	·435	·483	·530	·578	·627	·676
4500	·140	·189	·236	·280	·330	·379	·426	·472	·519	·566	·614	·661
4000	·137	·185	·231	·274	·323	·371	·417	·463	·508	·554	·601	·648
3500	·134	·182	·226	·269	·316	·363	·408	·453	·498	·543	·589	·634
3000	·131	·178	·221	·264	·310	·356	·400	·444	·488	·532	·577	·622
2500	·129	·174	·217	·258	·304	·349	·392	·436	·478	·522	·566	·610
2000	·126	·171	·213	·253	·298	·342	·385	·427	·469	·512	·555	·598
1500	·125	·169	·210	·250	·294	·338	·379	·421	·463	·505	·547	·590
1000	·122	·165	·205	·244	·287	·330	·371	·411	·452	·493	·534	·576
500	·119	·162	·202	·239	·282	·324	·364	·405	·444	·484	·525	·566
Sea Level	·117	·159	·198	·235	·277	·318	·357	·397	·436	·475	·515	·555

Fill phials with deci-normal baryta water, quantities calculated to values at 6000 ft. Check results against standard method. Difference will give factor for calculation of quantities of baryta water required for local conditions. Table then gives CO_2 values for varying depths.

The apparatus consists of the following:

1. A wooden case, 16½ × 8½ × 10½, with strap for carrying.
2. Bellows, fastened inside the lid of the case, as a safeguard against rats.
3. 18 1 oz. tincture phials with rubber corks.
4. Four sample bottles, technically known as 8 oz. flats.
5. One vulcanite or porcelain transferer with rubber washers.
6. One bottle holder (two designs).

1. If the pink colour is rapidly discharged the record is made of the number of the reagent bottle used, followed by a capital D thus 3D, which means that the percentage of CO_2 is in excess of the value given on the table for the level at which the sample is taken.

2. If the colour changes slowly and while not entirely discharging is faint, it may be taken that the table value of the bottle represents the actual percentage of CO_2, and the record is made 3N.

3. If the colour remains unchanged the percentage is distinctly lower than the value of the bottle, and the record 3U is made.

For example, at 2,500 ft. above sea level.
3D would represent "in excess of 0·217%."
3N would represent "0·217%."
3U would represent "less than 0·217%."

In these cases 3D would call for a wash down and blow out, with 3N such action would not be imperative, and with 3U it would be unnecessary.

TABLE OF COMPARATIVE RESULTS.

Date.	Percentage of CO_2		Date.	Percentage of CO_2	
	Standard Method.	S.F. Method.		Standard Method.	S.F. Method.
	%	%		%	%
2-9-18	·09	·10	8-11-18	·22	·25U
,,	·16	·15	,,	·17	·20U
,,	·15	·15	,,	·18	·20U
6-9-18	·25	·22D	,,	·29	·25D
10-9-18	·11	·16U	,,	·23	·25U
,,	·14	·16U	,,	·20	·20N
,,	·21	·20N			
,,	·38	·20D	1919		
		·25D		·419	·29
26-9-18	·21	·20U		·196	·18
,,	·23	·20U		·152	·15
,,	·26	·20D		·309	·24
,,	·23	·20U		·430	·27
7-11-18	·17	·20U			
,,	·13	·20U			
,,	·15	·20U			

N.B.—The samples estimated on the 26-9-18 afford an example of the effect of insufficient shaking; they were only shaken for two minutes

The above is a list of estimations made in conjunction with the standard methods, by different gentlemen quite independently of myself. It will be seen that in the range of the degree point, 0·20 , they agree. In the higher percentages the Safety First method has often given lower results; there are several possible disturbing factors which may account for these discrepancies, the most important being the personal equation, but in this paper it is unnecessary to discuss these factors, since the only claim at present made for the method under consideration is that it ensures safety. When the time comes for the method to be considered as a rival to the present standard one the effect of these factors will have been accurately determined.

The advantage of being able to ascertain with certainty the condition of the air in places such as winzes, raises, drives and back stopes, within a few minutes is obvious, and has been practically illustrated in a back stope, where day and night shifts have been worked for two months. The apparatus was in constant use, and tests were made invariably before the workers were allowed to enter.

Whenever high percentages were indicated it was found that there was some slight derangement of the ventilation, such as low pressure of air, lashing of ore heaps saturated with gas, etc. A wash down and blow out usually corrected the conditions and enabled work to commence in safety.

Generally and regularly used, the method should become as much a part of mine routine as is the search for misfires, or the examination of the hanging.

My thanks are due to Mr. Tucker, Geldenhuis Mines, and Mr. Hilton, City and Suburban G.M., for assistance in the construction of the apparatus, and to Messrs. Wartenweiler, Ingle, Blackmore, Touzeau-Brinton and many other gentlemen for assistance and advice in testing and sampling.

The President: I should like to propose a very hearty vote of thanks to the author for his bringing forward this very ingenious arrangement. It certainly seems a useful adjunct to the methods in vogue. I have never had the opportunity of seeing it before; so perhaps those who have, will contribute a remark or two as to their opinion of its utility.

Mr. J. Gibson *(Associate):* I have had the satisfaction of using this apparatus by the author on the Geldenhuis Deep. We applied it in the case of several back stopes which are contiguous to one another just near the Heriot boundary, and which gave us quite a lot of trouble in connection with ventilation. In testing we tried it for two or three days against the ordinary bottle

method, compared the results afterwards, and the tests compared very favourably, quite sufficient to give an indication as to whether the stopes should be entered or not before starting operations; and, as a quick method of ascertaining whether places which have accumulated bad air should be blown out or not before allowing boys or workmen to go in, I should say in this particular case the apparatus would be very useful. It is sufficiently accurate to give those indications, and it is not intended, of course, to do away with the ordinary methods of testing the air in those places where tests are necessary, but just as an indication as to whether they are in a dangerous state or in a safe state to work in. In these particular stopes we have tried quite a number of different methods of ventilation, and, finally, we have solved the difficulty by putting in a short length of about 80 ft. of 16 in. Hume pipe with an H.A.S. blower, which has given very great satisfaction. It has induced a sufficient draught to keep those places well ventilated.

The regulations require a minimum percentage of 0·2% CO_2 in the case of phthisis mines, and it has been found that where the CO_2 rises above 0·3%, an appreciable amount of CO may in many cases be present. The apparatus devised by Mr. Wilkes readily indicates such an amount of CO_2 by testing on the spot. Thus, when used in this manner, it will tend towards a reduction of minor gassing cases, especially in those workings where accumulations of CO_2 are probable, thereby also preventing delays when the tests show there is no danger in allowing work to proceed.

Mr. F. Wartenweiler *(Member of Council)*: I think the author has established a very happy precedent, and that is, that a newly elected member introduce himself by reading a paper.

I have not had experience with the author's apparatus, except on the surface, but it has appealed to me, from the beginning, as a rapid method—approximate, to be sure—just to tell the underground official whether the CO_2 content of a working place is either below the Government regulations and safe, or whether it is above and unhealthy. In that respect, I believe it will prove useful, and worthy of the attention of the underground staff.

DETERMINATION OF AVAILABLE LIME IN THE DIFFERENT CLASSES OF LIME SUPPLIED TO RAND REDUCTION WORKS.

By C. A. Meiklejohn (Member).

(Printed in Journal, December, 1918.)

DISCUSSION.

Mr. F. W. Watson *(Member of Council)*: In submitting a few remarks on Mr. Meiklejohn's paper on the determination of available CaO in ordinary commercial lime, I must, in the first place, express my regret that the author was unable to be present at a meeting to introduce his paper, as, I am sure, the points he has raised would have been emphasized.

Mr. Meiklejohn opens his paper with a description of the method recommended by the Standards Committee in January, 1913, and although the subject of determination of CaO has been well thrashed out in this Society's *Journal*, I think we should welcome the author's paper giving us his experience, as six years is a considerable interval, and in that time many analysts may consider that the method recommended can be improved upon.

In my opinion, the great point to be considered in the estimation of CaO is to bear in mind that quick-lime is what I might class as a "perishable" product. The sample, during handling, is liable to lose efficiency due to absorption of CO_2 from the surrounding atmosphere; aqueous vapour is also rapidly absorbed, increasing the weight, while the added weight is inert. For this reason I consider that grinding the whole sample in a Wedgwood mortar and passing the whole through a 60 mesh sieve (Standards Committee method) cannot be recommended as the best procedure, as this operation is bound to take a considerable time and most intimate contact with the surrounding atmosphere is ensured.

Sugar Solution.—The solution we use contains between 20 gm. and 30 gm. of sugar to the litre. Each litre of solution is made up separately, and is prepared just prior to commencing the estimation. A stock solution of sugar should not be kept as fermentation may be set up. The litre of sugar solution is poured into an ordinary Imperial quart bottle (colourless glass), as this is most conveniently handled, and the solution is then neutralized to phenolphthalein.

I am of opinion that phenolphthalein is the correct indicator to use in this operation, as H_2CO_3 is the acid to be neutralized, and phenolphthalein is undoubtedly more sensitive to this weak acid than rosolic acid. It must be remembered that in the final titration of the caustic lime carbonates are, to all intents and purposes, eliminated, so that the use of the same indicator in neutralizing the sugar solution and in the lime titration has not so much to recommend it as might appear at first sight.

In neutralizing the sugar solution we use ordinary deci-normal caustic soda and run it in from a burette. By this means we know how much excess volume we have added and we then pipette an equal quantity out of the bottle.

We have found that in distilling ordinary Rand Water Board water, if the distilled water is stored in Winchester quart bottles, a very considerable difference in CO_2 content will be found in different bottles collected from the same still. At the present time we stock our distilled water in a large covered earthenware jar holding about 60 litres, and thus we obtain uniformity, very little alkali being required for neutralization. I have known a litre of sugar solution, prepared with distilled Rand Water Board water, require as much as from 15 cc. to 20 cc. of deci-normal alkali to show the phenolphthalein colour. This may seem incredible, but can be explained by assuming that this particular bottle of water had been collected during the period of maximum decomposition of the bicarbonate of lime originally present in the natural water. This will emphasise the point raised regarding our preference for phenolphthalein as indicator in neutralizing the water.

Preparation of Sample.—The sample, according to the standard specification, is supposed to have been passed through a 30 mesh sieve, and in this state of fineness I consider it is quite permissible, in fact preferable, to further reduce the bulk before any subsequent grinding. The method proposed by Mr. G. W. Williams in 1905, and since then invariably used in the Consolidated Gold Fields Laboratory, consists in mixing the sample thoroughly on a paper, spreading it out and taking about 30 gm. to 40 gm. This quantity is ground in a Wedgewood mortar, which not only reduces the sample to a fine state of division, but insures an intimate mixture, and about 5 gm. of this is taken and finely pulverised in an agate mortar. From this finely pulverised portion 2 gm. is immediately weighed out for the estimation and added to the litre of sugar solution prepared as described above. The bottle is *at once* shaken thoroughly by hand to prevent coagulation of the lime. This we have found a most important factor, and neglect of this may, in some cases, cause low results. The bottle is then agitated for about half an hour by hand, then mechanically agitated for about an hour and allowed to stand overnight. In the morning it is mechanically agitated for about half an hour, then allowed to settle and 25 cc. of the clear solution pipetted off and titrated with N/10 sulphuric acid, rosolic acid being used as indicator.

I cannot agree with Mr. Gray that standing overnight tends to give low results, and would like more than a vague statement that this is well known by those familiar with lime determinations. It seems to me that such a statement should have more foundation from the standpoint of chemical theory. Where, in a sealed bottle, does the baneful influence gain admission, and what precipitates the dissolved lime or prevents solution? We have experimented with lime samples, giving different treatments in the matter of agitation, and have found that the method just described gives as high a result as either two hours' continuous or six hours' intermittent agitation.

I agree with Mr. Meiklejohn that filtering the solution is unnecessary and a waste of time. A solution of caustic lime, if allowed to stand, settles readily, and it is an easy matter to draw off enough absolutely clear solution for several titrations of 25 cc. each. We have discarded filtering for the last three or four years as we found that the difference between the results obtained by our previous method of filtering and by drawing the solution off was inappreciable, and there is no comparison in the time taken. It may be remarked that the filter paper used by the author (30 c.m. diameter) seems unnecessarily large, 18·5 cm. and 15 cm. diameter are the sizes we used in days gone by.

Mr. Meiklejohn seems to have gone to a great deal of trouble and spent a considerable amount of time in preparing his paper. While I agree with him that, in my opinion, the standard method is not by any means the last word in available lime determination, and that in all cases agitating the sam-

ple is advisable (in some cases absolutely necessary), I feel that a great deal of his work has been unnecessary and might have been avoided if he had made enquiries before undertaking such elaborate experiments.

It seems strange that one should have, at this time, to comment on such a largely used method as available lime determination, but I would be greatly interested to really know how many analysts actually carry out the standard method to the letter.

NOTES ON THE FOOTWALL BEDS OF THE FAR EAST RAND REEF.

By L. W. Macer (Associate).

(Printed in Journal, November, 1918.)

REPLY TO DISCUSSION.

Mr. L. W. Macer *(Associate)*: I do not think there is much in the discussion which has taken place on this paper which calls for reply.

In reply to Mr. H. S. Meyer's remarks, I may say that illustration Fig. 1 was taken from the same drive as was Dr. Mellor's, but I believe on the opposite side of that drive. My point was to illustrate the intrusive nature of the slate, this being the most striking occurrence of this phenomenon that I know of at Brakpan. It is unfortunate that the illustration has been printed upside down, which fact, however, might have called forth comment where the geological interest of the section failed to do so.

I am in agreement with Mr. Bleloch in urging that mining men should record their observations upon the mineralogical and geological characteristics of the reefs and adjacent beds, and would suggest that this Society take steps to encourage such work. I have recently been much impressed by the absolutely useless nature of many of the shaft and borehole records which it has been my lot to examine. Surely the results of such expensive works are worthy of skilled examination and careful record. The geological record of underground development work is often no better, with the result that one so often comes across work which is more worthy of moles than mining engineers. I am inclined to think that had underground men been encouraged to observe and record their observations as to the geological side of their work there would now be little room for controversy amongst geologists as to the stratigraphy of these fields.

THE APPLICATION OF THE THEORY OF PROBABILITY IN THE DETERMINATION OF ORE RESERVES

By G. A. Watermeyer, B.A., A.R.S.M. (Member of Council).

(Printed in Journal, January, 1919.)

DISCUSSION.

Sir Robert Kotzé *(Member)* *(contributed)*: I have read the paper carefully, but found it difficult to follow. There are some misprints of formulae, and unless one has the original authorities the mathematical development is incomplete. That does not matter much in general, but there is one step for which the reason ought to be shown. It is not contained in the paper, and I shall endeavour to explain it as follows:—

The new method consists in working out a smooth frequency curve from a more or less erratic frequency polygon obtained when plotting the observed frequencies of the various inch-dwts. arranged in sets of 50 or so. This curve is presumably that for the whole mine or whole section of a mine. For a particular section or series of values forming presumably part of such a whole, the actual inch-dwts. forming the series are weighted with frequencies shown in the smooth frequency curve and the mean thus ascertained.

It is difficult to see the logic of this procedure. Probably it is developed in the authorities quoted. If it were strictly correct in all cases it would be correct in the extreme case—that is in the case where the section to be tested consists of the original samples of the whole mine or whole sections of a mine from which the curve is constructed. But obviously it is not correct in that case for the frequency would then appear as a double multiplier. For example, the table on p. 105 means that there were in the original samples for every 466 samples of 25 inch-dwts., 869 samples of 75 inch-dwts., etc., etc. If the method illustrated at the beginning of p. 106 is correct it can also be applied to the whole mine that is to the table on p. 105. You would then have 466 samples grouped around 25 inch-dwts. with a weight of 4·66, 869 samples grouped around 75 inch-dwts. with a weight of 8·69, etc. obviously you would multiply twice by 4·66, 8·69, etc., in this way (neglecting the 100 factor).

The logical reasoning for this step ought to follow immediately after the table on p. 105 before proceeding to give the illustration following. I take it the table on p. 106 means that one sample of group 520 has been found, one of 340, etc., and not more than one. Further, I presume the method is to be applied to rock coming from all over the mine and not to individual blocks.

It would be useful to consider a mine as a bag full of so many million counters, each representing 5 lb. The sampler is the man who takes out the counters one at a time, and he finds each one marked with its dwt., and on the theory of probabilities proceeds to work out the average. The probability of a shovelful of such counters taken out of the bag would represent one particular series. The development of this idea might give some enlightening results.

I think the author is to be congratulated in having tackled in a new way a problem which has puzzled a great many of us at one time or another. The complete elimination of high samples or their reduction to some figure commensurate with the average of the block value or series of samples has probably never satisfied anyone as being logically dependable. Yet these have been the only methods in use up to the present.

Perhaps the author can also indicate to us the approximate number of samples required to give the true value of a block within a required limit of error. Experience has shown that samples must not be taken too far apart to give reasonably reliable results, but the theoretical basis for this procedure still awaits demonstration.

The meeting terminated at 10.20 p.m.

Obituary.

SIR WILLIAM CROOKES, O.M.

(Hon. Member).

Sir William Crookes, English chemist and physicist, whose death took place in London, on Friday, the 4th April, was born in London on the 17th of June, 1832, and studied chemistry at the Royal College of Chemistry under A. W. von Hofmann, whose assistant he became in 1851. Three years later he was appointed an assistant in the meteorological department of the Radcliffe Observatory, Oxford, and in 1855 he obtained a chemical post at Chester. In 1861, while conducting a spectroscopic examination of the residue left in the manufacture of sulphuric acid, he observed a bright green line which had not been noticed previously, and by following up the indication thus given he succeeded in isolating a new element, thallium, a specimen of which was shown in public for the first time at the exhibition of 1862. During the next eight years he carried out a minute investigation of this metal and its properties. While determining its atomic weight, he thought it desirable, for the sake of accuracy, to weigh it in a vacuum, and even in these circumstances he found that the balance behaved in an anomalous manner, the metal appearing to be heavier when cold than when hot. This phenomenon he explained as a "repulsion from radiation," and he expressed his discovery in the statement that in a vessel exhausted of air a body tends to move from another body hotter than itself. Utilizing this principle he constructed the radiometer, which he was at first disposed to regard as a machine that directly transformed light into motion, but which was afterwards perceived to depend on thermal action. Thence he was led to his famous researches on the phenomena produced by the discharge of electricity through highly exhausted tubes (sometimes known as "Crookes' tubes" in consequence), and to the development of his theory of "radiant matter" or matter in a "fourth state," which led up to the modern electronic theory. In 1883 he began an inquiry into the nature and constitution of the rare earths. By repeated fractionations he was able to divide yttrium into distinct portions which gave different spectra when exposed in a high vacuum to the spark from an induction coil. This result he considered to be due, not to any removal of impurities, but to an actual splitting-up of the yttrium molecule into its constituents, and he ventured to draw the provisional conclusion that the so-called simple bodies are in reality compound molecules, at the same time suggesting that all the elements have been produced by a process of evolution from one primordial stuff or "protyle." A later result of this method of investigation was the discovery of a new member of the rare earths, monium or victorium, the spectrum of which is characterized by an isolated group of lines, only to be detected photographically, high up in the ultra-violet; the existence of this body

was announced in his presidential address to the British Association at Bristol in 1898. In the same address he called attention to the conditions of the world's food supply, urging that with the low yield at present realized per acre the supply of wheat would within a comparatively short time cease to be equal to the demand caused by increasing population, and that since nitrogenous manures are essential for an increase in the yield, the hope of averting starvation, as regards those races for whom wheat is a staple food, depended on the ability of the chemist to find an artificial method for fixing the nitrogen of the air. An authority on precious stones, and especially the diamond, he succeeded in artificially making some minute specimens of the latter gem; and on the discovery of radium he was one of the first to take up the study of its properties, in particular inventing the spinthariscope, an instrument in which the effects of a trace of radium salt are manifested by the phosphorence produced on a zinc sulphide screen. During the subsequent thirty years of his life, Crookes was much occupied with further experimental work on questions cognate to these subjects. His familiarity with spectroscopy enabled him to pursue successfully an enquiry into the preparation of eye-preserving glass for spectacles, the results of which were published in the Philosophical Transactions so recently as 1914, and have led to valuable practical results, especially in the case of workers in glass and others exposed to furnace glare. The primary object was to find a glass which will cut off as much as possible of the heat radiation, but the experiments were extended to the search for glasses opaque to the ultra-violet. More than three hundred different glasses were investigated, and the compositions of nineteen which have been proved useful are given in the memoir. In addition to many other researches besides those here mentioned, he wrote or edited various books on chemistry and chemical technology, including "Select Methods of Chemical Analysis," which went through a number of editions. He further published "The Manufacture of Beet Root Sugar in England," 1870; "Handbook of Dyeing and Calico Printing," 1874; "Dyeing and Tissue Printing," 1882; "Kerl's Treatise on Metallurgy," 1868; "Wagner's Chemical Technology"; "Auerbach's Anthrasen and its Derivatives," 1890; "Ville's Artificial Manures," 1909; "The Sewage Question"; "The Wheat Problem," 1899; "Diamonds," 1909. He also established the *Chemical News*, of which he remained the proprietor and editor until his decease.

He also gave a certain amount of time to the investigation of psychic phenomena, endeavouring to effect some measure of correlation between them and ordinary physical laws. Besides many scientific distinctions he was knighted in 1897, and made a member of the Order of Merit in 1910, and received the Royal (1875), Davy (1888), and Copley (1904), medals of the Royal Society, besides filling the offices of President of the Royal Society, Chemical Society, Society of Chemical Industry, British Association for the Advancement of Science, and of the Institution of Electrical Engineers. The honorary degree of D.Sc. was conferred upon him by various Universities, including the University of the Cape of Good Hope, and he had been an honorary member of our own Society for many years prior to his death.

During his first visit to South Africa, he addressed a meeting* of our Society upon the liquefaction of gases, on 22nd February, 1896, in the Chamber of Mines Building, on which occasion Mr. A. F. Crosse was in the chair. His second visit to South Africa took place as a member of the British Association for the Advancement of Science in 1905, when he delivered an address at Kimberley upon diamonds, and demonstrated their hardness by causing one to become embedded in a steel plate under hydraulic pressure, applied slowly.

His first arrival on the Witwatersrand coincided with the stirring times of the Jameson Raid. On this occasion he accompanied Mr. J. S. MacArthur and other representatives of the African Gold Recovery Company, for whom he gave evidence in Pretoria in the great cyanide case. The writer had the privilege of being associated with Sir William (then Professor) Crookes in this work, and was much struck by his keen interest in Rand activities and life, including his absorbed attention in the making of fire by two natives rubbing two sticks together. When this conversion of molar into molecular motion had been successfully accomplished, the Professor lit a cigarette at the resulting flame and handed over the promised half-crown to the mutual satisfaction of himself and the exponents of a primitive art.

*See Vol. I. of this Journal, pp. 212-7.

Crookes was a man of extraordinary genius and immense physical activity, of which his copious published work is evidence. He combined with his intellectual powers an unusual degree of genial kindness and consideration for others. There were two terms that he called "bad words," and would not allow in the laboratory—one was "cannot," the other "near enough"; and one of his favourite sayings was that a man could not be really happy unless he had just a little more to do each day than he could possibly finish.

The writer will ever bear in appreciative remembrance the courteous hospitality extended during a visit to England in 1907.

W. A. C.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Extraction of Potash from Kelp.—"The extraction of potash from seaweed by incineration is very costly, and will probably continue only as long as the present high price of potash is maintained. Even under modern methods, the cost of harvesting alone, in Californian coastal waters, amounts to about $1.10 (4s. 7d.) per ton of raw kelp containing 1·3% K_2O; which is equivalent to about $85 (say £18) per short ton of K_2O, without the cost of drying and incineration. In a process operated successfully by the Hercules Powder Co., San Diego, Cal., since 1915, raw kelp is fermented with the production of acetic acid. Fermentation is allowed to proceed until the greater part of the kelp leaf dissolves, when the insoluble residue is removed by screening, and the solution is then neutralised with limestone. The liquid is concentrated and three products are obtained at various stages, the first consisting mainly of calcium acetate and potassium chloride, the second of the calcium salts of acetic, propionic, butyric, and valeric acids, and the third containing the bulk of the potassium iodide. The first product is distilled to recover acetone and acetone oils, and the residue lixiviated for potassium chloride; the second is treated with alcohol and sulphuric acid for the production of ethyl esters which are afterwards separated by fractionation; and the third is treated with chlorine for the production of iodine which is subsequently recovered by sublimation. The residual unfermented leaves are treated with sodium carbonate to extract, in the form of a soluble salt, algin which is afterwards precipitated and purified. Algin may find extensive uses in the future as a substitute for gelatin and vegetable gums. Probably the total production of all the harvesting concerns in present operation (in the U.S.A.) does not exceed 25 tons of 80% potassium chloride per day; and of this more than half is recovered in the form of high-grade salt (95% KCl) by the fermentation process."—C. A. Higgins, *Chem. and Met. Eng.*, 1918, *19*, 432-433. —*Journal of the Society of Chemical Industry*, Nov. 15, 1918, p. 653A. (J. A. W.)

Estimation of Cadmium in Zinc.—"I have done a considerable amount of work in the analysis of zinc slab and spelter, using exclusively the method approved by the American Chemical Society (*Journ. Ind. & Eng. Chem.*, Vol. 7, No. 6, pp.547-548), and have evolved a modification of the method prescribed for the determination of cadmium, whereby from three to four hours is saved in the analysis. The principles involved are identical with the original scheme, but the details and manipulation vary somewhat.

Twenty-five grams of borings are weighted out into a 500 cc. beaker, 250 cc. water, and 59 cc. concentrated HCl added. The beaker is placed upon a low hot plate, and allowed to stand overnight. In the morning, it will be found that all but a gram or two of the zinc has been dissolved, and the cadmium is untouched. Filter, transferring a piece of the undissolved zinc first to the filter paper, wash two or three times with hot water, and wash the residue into a 500 cc. casserole. Add sufficient nitric acid to dissolve, keeping covered meanwhile with a watch-glass, add 20 cc. of 1 : 1 sulphuric acid, and evaporate to sulphur trioxide fumes. Allow to cool, add 150 cc. hot water, and bring just to a boil. The precipitated lead sulphate may be filtered off immediately.

Collect the filtrate in a 350 cc. beaker, dilute to 200 cc., and add 5 cc. of a saturated solution of ammonium chloride. Pass hydrous sulphur through the solution for half an hour. A drop or two of ammonia may be necessary to start precipitation. The official method recommends the hydrogen sulphide for one hour, but I have found half this time with a steady stream to be ample. Remove beaker from generator, retaining tube for use as a stirring rod.

Filter rapidly through a double 12½ cm. No. 41 Whatman paper, wash two or three times with hot water and transfer paper entire to a 150 cc. beaker. Do not scrub the sides of the beaker to remove adhering particles of sulphide. Pour 60 cc. of 1 : 5 sulphuric acid into beaker upon filter paper, and break up latter with a stirring-rod. Boil until all sulphide has been decomposed. Filter at once into original beaker in which precipitation was made, dilute to 200 cc., add 5 cc. ammonium chloride solution, and re-precipipitate as carmium sulphide, using original glass tubing as hydrogen sulphide conveyor. Filter, and wash slightly, as before. Transfer filter paper to original beaker in which precipitation was made, and boil up with 60 cc. of a 1 : 3 hydrochloric acid solution. Add a few drops of nitric acid in order to oxidise the sulphur.

When dissolved, filter into a 200 cc. electrolytic beaker, and wash three times. Add a few drops of phenolphthalein, then an excess of a saturated NaOH solution, until a deep red is obtained. Add a freshly prepared saturated solution of KCN until the precipitated cadmium hydroxide redissolves. Electrolyse, keeping solution stirred by air or mechanically. All the metallic cadmium is deposited within half an hour. Strict adherence to the directions prescribed by the official method lengthens the time for the determination by at least four hours. Weighing a sample at 5 p.m., before stopping work, and digesting it overnight, makes it possible to finish the determination before noon the following day."—H. Isaacs, *Chemical Analyst.*—*Engineering and Mining Journal*, Sept. 28, 1918, p. 584. (H. A. W.)

AMERICAN COAL TAR PRODUCTS IN 1917.—"The United States Tariff Commission has just completed its census of products for 1917, and pending the publication of its final report, the following facts are available.

Dyes.—There were 81 establishments engaged in the manufacture of dyes in 1917, and the total production amounted to 45,977,216 lb. valued at $57,796,027. In quantity, this is practically identical with the imports before the war, but the nature of the dyes is very different. Thus, the highly important indigoid and alizarine vat dyes, after subtracting the extract prepared from imported indigo, only amount to 3% of the pre-war imports. The lack of development in this class should be remedied this year as several firms have begun the manufacture of various members of the group and a large increase in the production is expected. The production of other classes of dyes shows big increases, a surplus being available for export. During the fiscal year 1917, American-made dyes to the value of $11,709,287 were exported.

Intermediates were manufactured by 117 firms, the total production being reported as 322,650,531 lb., valued at $106,942,918. These figures are really too high, since a complex derivative is reported as well as the simpler derivatives from which it is derived. Thus each product in the chain, nitrobenzene, aniline, acetanilide, nitroacetanilide, and nitraniline would be reported separately and the total is thus greatly swollen. Other products included 5,092,558 lb. of colour lakes valued at $2,764,064; 2,236,161 lb. of medicinal chemicals, valued at $5,560,237; 779,416 lb. of flavours, valued at $1,862,456; 263,068 lb. of photographic chemicals, valued at $602,281; and 19,545 lb. of perfumes, valued at $125,960."—*Oil, Paint and Drug Rep.*, June 10, 1918.—*Jour. Soc. Chem. Ind.*, July 31, 1918, p. 288R. (A. W.)

RECOVERY OF SELENIUM AND TELLURIUM IN COPPER REFINING.—"In the electrolytic refining of crude copper bullion the selenium and tellurium present are concentrated in the anode slime, from which they are recovered in various ways. (1) The button of noble metals obtained by cupellation of the slimes with lead is fused with sodium carbonate and nitrate; the 'nitre slag,' which contains the bulk of the selenium and tellurium, is extracted with hot water, giving a solution of selenite and tellurite. (2) The flue system of the cupellation furnace is equipped with a scrubber or Cottrell apparatus. In both cases it is necessary to saturate the gases with water, and the water, after being circulated repeatedly, forms a cheap source of selenium. The wet sludge from the scrubber is filter-pressed. (3) The flue-dust, or the filter-pressed sludge from (2) is roasted at a low red heat; crystals of selenium dioxide are obtained by cooling the roaster gases in chambers. (4) The flue dust, instead of being roasted, may be extracted with water, selenium dioxide dissolving. The residue is treated with sulphuric acid and bleaching powder, whereby the elementary selenium is oxidised and dissolved. The alkaline solution obtained under (1), on being acidified with sulphuric acid, yields a precipitate of tellurous acid. The acid filtrate, or the solutions obtained under (2) or (4), are reduced with sulphur dioxide to precipitate the selenium. The latter is washed free from acid and digested with boiling water to transform it into the [illegible] modification. The dried tellurous acid precipitate is reduced with [illegible] black or ground charcoal in a [illegible] furnace and cast into cake or [illegible] form. Alternatively, the tellurous acid may be dissolved in four parts of strong hydrochloric acid and the solution precipitated with sulphur dioxide, the [illegible] being diluted but not to such a degree as to [illegible] precipitate tellurous oxide." M. H. MORGANS and H. T. BINDER, *Eng. and Min. J.*, 1918, [illegible] 413 [illegible].—*Journal of the Society of Chemical Industry*, Nov. 15, 1918, p. 607A. (J. A. W.)

RELATIVE EFFICIENCY OF MOTOR FUELS.—"In a newly published book 'Die Treibstoffe der Kraftfahrzeuge,' by Donath and Gieger (Berlin, Springer, 1917), an account is given of experiments with different motor fuels recently carried out in Germany. The following were some of the results obtained:—

Petrol, pure	5·8 km. per litre
Benzol, pure	7·1 ,, ,,
1 Benzol + 1 Alcohol	7·5 ,, ,,
1 ,, + 2 ,,	7·2 ,, ,,
1 ,, + 3 ,,	7·0 ,, ,,
1 ,, + 4 ,,	6·9 ,, ,,
1 ,, + 5 ,,	6·0 ,, ,,
Alcohol, pure	5·4 ,, ,,

—*Teknisk Ukeblad*, Christiana, April, 1918.—*Journal of the Society of Chemical Industry*, June 29, 1918, p. 210R. (J. A. W.)

USE OF NITRE-CAKE IN THE MANUFACTURE OF SUPERPHOSPHATE.—"A successful process is in use for the manufacture of superphosphate from Tunisian phosphate and nitre cake. The nitre-cake is ground in an ordinary disintegrator and if ground phosphate is gradually mixed with it during the grinding clogging of the machine is obviated. It has been found necessary to add to the mixing about 10% of hot water more than is present when sulphuric acid of 118° Tw. (sp. gr. 1·59) is used. Comparatively little heating or evolution of gas occurs. Analysis of the product (after two weeks) gave 16·36% of water soluble phosphate."—51th Annual Report on Alkali Works for 1917 by the Chief Inspector, 19-20.—*Journal of the Society of Chemical Industry*, September 16, 1918, p. 522A. (J. A. W.)

DETERMINATION OF NITRITES.—"Nitrites react with hydriodic acid according to the equation:

$$NaNO_2 + 2HI = NaI + I + NO + H_2O.$$

For the estimation three flasks containing respectively 50 cc. of 4% potassium iodide solution, 10 cc. of N/1 sulphuric acid, and the solution of the nitrite, are connected in the order named and the air is displaced by a current of carbon dioxide. By means of this gas the potassium iodide solution is then driven over into the sulphuric acid, and then the mixture in the second flask into the third containing the nitrite solution. The liquid is then made alkaline by the addition of 10 cc. of a 20% solution of ammonium carbonate and titrated with N/70 arsenious acid solution, of which 1 cc. = 0·2 mgm. of nitrous nitrogen. Care must be taken to avoid the presence of oxygen until the solution is made alkaline."—F. DIENERT, *Comptes rend.*, 1918, *167*, 366-367.—*Journal of the Society of Chemical Industry*, Oct. 31, 1918, p. 621A. (J. A. W.)

Determination of Molybdenum in Ferro-Molybdenum. "From 0·5 to 1·0 gm. of ferro-molybdenum is decomposed by fusion with 10 gm. of sodium peroxide in an iron crucible, the melt dissolved in warm water, boiled for a short time, and washed into a 500 cc. flask. After settling, 100 cc. of the liquid is neutralised with acetic acid, the solution boiled for a short time, and the following freshly prepared solutions quickly added in succession: (1) 2—5 gm. of lead acetate and 2 cc. of acetic acid in 50 cc. of water, and (2) 10 gm. of ammonium acetate in the same quantity of water. Boiling is continued for a few minutes and the solution is then allowed to stand for six hours, after which it is filtered through filter-pulp. The precipitate is washed with about 200 cc. of ammonium acetate solution, and is then transferred, together with the moist filter-pulp, to a beaker in which it is heated to boiling with 20 cc. of dilute nitric acid, after which a solution of 10 gm. of ammonium acetate and 5 cc. of dilute acetic acid in 50 cc. of water is added. The solution is boiled for one to two minutes, filtered after 12 hours, and the residue, after having been washed with hot ammonium acetate solution until the filtrate is free from lead, is dried, incinerated at the lowest possible temperature, ignited, and weighed as $PbMoO_4$."—R. Strebinger, *Oesterr. Chem. Zeit.*, 1917, *20*, 226-228; *Z. angew. Chem.*, 1918, *31*, Ref., 278.—*Journal of the Society of Chemical Industry*, Oct. 31, 1918, p. 625A. (A. W.)

Industrial Developments Relating to the Manufacture of Acetic Acid and Acetone.—"On the oubreak of war the demand for acetic acid and acetone rose to such an extent that the output of the wood-distillation industry was totally inadequate to meet the requirements. Working in conjunction with the British Government, the U.S. Industrial Chemical Co. erected a large plant which is now producing acetic acid by the oxidation of alcohol obtained from molasses by the quick fermentation process. The plant has an output of 70,000 lb. of acetic acid (calculated at 100%) per day. The oxidation of the alcohol to acetic acid is effected in generators filled with beech shavings. It is most probable that this process will not be profitable under normal conditions. Acetone is also produced in Toronto and in the United States by the Fernbach process, in which starch from maize or other grain is fermented by a special ferment, which resolves the carbohydrate into a mixture of butyl alcohol and acetone. The output of acetone at the Toronto plant is 100 tons per month, and at the United States plant nearly 250 tons. A process has been worked out into operation in Canada (output 56,000 lb. of 100% acetic acid per day) which is based on the German patents for the manufacture of acetic acid from acetylene. When acetylene gas is passed through a solution of a mercury salt in dilute acid, it combines with the water yielding acetaldehyde, which is readily converted by atmospheric oxygen into acetic acid. The process is important as a potential source ultimately of cheap acetic acid, and of acetaldehyde for probable new industrial uses. In Germany and in Switzerland large electrical installations have been erected for the manufacture of alcohol and acetic acid from calcium carbide. The wood-distillation industry is threatened with dangerously keen competition in the future. Development on scientific lines, and research for the exploitation of untapped sources of revenue in the acetone, crude acetone oils, and wood tar are imperative"—H. Hibbert, *Chem. and Met. Eng.*, 1918, *19*, 397-400.—*Journal of the Society of Chemical Industry*, Nov. 15, 1918, p. 671A. (J. A. W.)

METALLURGY.

Refractory Properties of Magnesia.—"Magnesia is now largely employed in the manufacture of high-grade refractory materials, the use of which in steel works has kept pace with the development of the basic process. In this process, the refining of the metal is effected in presence of a slag rich in lime—that is to say, highly basic, the result being to eliminate not only carbon, silica, and manganese from the cast iron, but also phosphorus, which cannot be removed in the presence of a slag rich in silica, *i.e.*, of acid character.

It would be impossible to make use of basic slags in a furnace lined entirely with silica or clay bricks, as these materials weaken too quickly in the presence of lime. Magnesia bricks, on the contrary, being themselves basic in composition, offer complete resistance. In all basic furnaces the lower part of the vertical walls, and often the sole itself, is built of magnesia, the arch, however, being always composed of silica bricks.

Magnesia bricks are extremely refractory. Pure magnesia melts only at a temperature of 2,400°, or thereabouts—a temperature 700° higher than that of the steel furnace. Still, pure magnesia is never used in the manufacture of bricks, variable proportions of iron oxide being added—an addition of which gives to the bricks their brownish hue. This iron may also be present as carbonate, in the raw material, isomorphically mixed with the native carbonate of magnesia. The brick also contains silica and a little alumina, derived probably from the magnesium silicates associated with the coal, or else from the ash of the fuel used in the firing process. All these impurities necessarily increase the fusibility of the mass.

The writers, in giving their conclusions after tests on the refractory properties of magnesium bricks, add the comparative results of their experiments on a ferro-chromium brick. In building the furnaces such brick is employed, in order to separate magnesium bricks from the silica bricks, since the direct contact of the basic and acid materials would provoke mutual fusion. Ferro-chrome, on the contrary, acts neither on the silica nor on the magnesia bricks.

The test pieces were the ordinary bricks or specimens made at the laboratory. To obtain a standard for comparison, an attempt was made to prepare a block of very pure magnesia by melting the precipitated magnesia in the electric furnace; but at the high temperature necessary for this fusion, the lime of the furnace walls and the impurities present volatilised and affected the mass. Therefore, a combined mass, containing only 94% of magnesia—just about equal to a well-made factory brick—was obtained.

The following is a list of the test pieces:—(1) Styria brick, baked at 1,450°, made in 1890, ordinary quality; (2) Eubee brick, made in 1910, good quality; (3) brick G, good present day manufacture; (4) Brick B, mediocre quality, made with 3% of roasted pyrites added to the paste; (5) pure

magnesia, melted in the electric furnace; (6) premier matter for B agglomerated in the electric furnace; (7) ferro-chrome brick.

Crushing Strength.

(Kilogrammes per square centimetre.)

Temperature, °C. ...	15	1000	1300	1500	1600
1	145	85	66	3·6	1·8
2	120	—	—	185	8
3	390	—	—	K90	1·8
4	230	—	—	16	3·5
5	—	—	—	K90	6·6
6	530	—	—	—	50·0
7	260	120	6	2	1

In further experiments carried out on Nos. 1 and 2, there appeared a sharp decline in the crushing strength for the Styrian brick (the less pure of the two, between 1,300° and 1,400°, and the same for the Eubec brick, 1,500° and 1,600°. All magnesia bricks exhibit this sudden drop in resistance at a more or less high temperature, according to their degree of purity. It would appear as though, at a high temperature, the foreign ingredients suddenly melt in such a way as to leave the grains of magnesia isolated in the molted magma; they are then like wet sand, and possess only a feeble mechanical resisting power. The best magnesia bricks exhibit at 1,600° a crushing strength much inferior to that of good silica bricks. Moreover, at these high temperatures deformation of the magnesia bricks is to be expected as with clay bricks, but they give way gradually instead of breaking abruptly like the silica type. In cooling the weakened part resumes its hardness after the solidification of the molten magma.

Chemical Analysis.

	1	2	3	4	5	6	7
Magnesia	80·7	93·1	89·4	81·2	93·7	88·5	12·3
Lime	1·0	3·7	1·5	1·8	2·7	4·5	5·8
Iron oxide (Fe_2O_3)	6·0	0·5	1·1	1·2	0·3	1·1	*15·5
Alumina	0·6	0·2	0·8	1·0	1·1	0·0	10·9
Silica	6·7	2·8	1·2	8·8	3·2	6·5	4·7
Chrome oxide	—	—	—	—	—	—	50·0
Manganese oxide	—	—	—	—	—	—	1·5
Totals	101·0	100·6	100·0	100·0	101·0	100·9	100·7

* FeO.

The results of the experiments explain why magnesia bricks in furnace linings present less resistance than silica, although their fusion temperature (when sheltered from all mechanical stress) may be remarkably higher—2,050° C. instead of 1,750°.

The rate of the drop in resistance observed in the ferro-chrome brick is analogous to that of the magnesia, with a much lower temperature for rapid loss of solidity, viz., 1,100° instead of 1,350-1,550°, according to the purity of the magnesia."—H. Le Chatelier and B. Bogitch.—*Chemical Engineering and Mining Review*, July 5, 1918, p. 321. (H. A. W.)

MISCELLANEOUS

Costs and Profits of Low Temperature Carbonization of Coal.—"*Cost of Plant.*—This would depend on the type of installation that would be found serviceable. At first sight a low temperature plant working at only 500° C. would be less costly than a coke-oven plant working at 1,000°. If the stationary type of retort were erected, this factor would be counterbalanced by the greater number of units found necessary, whilst the price of a continuous retort would be increased owing to the engineering devices found necessary. The cost of a 300 tons a day coking plant before the war would be approximately £50,000 to £60,000, and this figure has been taken as representing the capital outlay.

Coal. The value of the coal and the resulting fuel would be interdependent; for that reason, the price of the coal has been arbitrarily fixed at 10s. per ton of unwashed small.

Labour is figured at 2s. per ton of coal carbonized.

Power, steam, etc.—This figure would again vary with the type of plant erected. In a vacuum plant the power consumption would exceed that of a coke-oven plant, and the same thing would apply in the case of certain types of continuous plants. For purposes of estimation the figure of 1d. per ton has been taken as the cost of steam and power.

Repairs and maintenance. The advantages of working at low temperatures would in this case again be counterbalanced by the increased number of units. In the case of continuous plants this figure would probably be high, but it would be counterbalanced by reduced labour charges.

Depreciation and interest is assumed to be 15%.

Stores, etc.—A figure of 2d. per ton has been assumed.

The following is an estimate of the expenditure in a plant carbonizing 300 tons of coal per day. Assuming 300 working days a year, 90,000 tons of coal per annum would be treated.

Coal washing.—Assume unwashed coal at 10s. per ton. Cost of washing 6d. per ton. Assume 25% loss in washing. Then cost of coal to ovens = 14s.

Expenditure.	£
Coal, 90,000 tons at 14s.	63,000
Labour	9,000
Repairs and maintenance ...	1,500
Steam and power	1,500
Interest and depreciation ..	9,000
Stores	750
	£84,750

Receipts would be made up of the values of the coke, tar, sulphate of ammonia, and light spirit produced.

Coke.—The character of the resulting smokeless fuel would depend on a number of factors, the most important being the nature of the coal used, temperature of carbonization, time of carbonization, thickness of coal charge, type of retort used, and gas pressure under which carbonization is effected. Of these the first is easily the most important. As a general rule the coke from highly oxygenated coals (humic coals) has a higher calorific value than the coals themselves, while with other coals the calorific value is lower. Fur-

ther, humic coals yield a friable powdery coke, whilst resinous coals yield a porous coke which is, however, fairly strong if carbonized under suitable conditions.

By judiciously mixing the coals used an excellent product can be obtained which has qualities which make it superior even to the large coal. In most low temperature schemes it is assumed that the resulting fuel has a value (on a pre-war basis) of from 25s. to 35s., but if low temperature carbonization were adopted on a large scale it is extremely doubtful whether the price would be much greater than that of the large coal.

As a general rule the difference in price between large and small coal varies from 7s. to 10s. per ton. With the small coal in this case at 10s. per ton, and allowing for the fact that it has been washed, it is perfectly justifiable to take the value of the resulting fuel at 20s. per ton.

For purposes of this estimate it is assumed that the yield of large fuel is 70%, together with 10% of breeze. The breeze could probably be reduced by the preliminary preparation, but even then it would be higher than is the case in coking practice.

The value of the breeze is taken as being equal to that of the initial unwashed small coal.

Tar.—The value of this substance is difficult to ascertain under present conditions. Further, the cost of purification is difficult to calculate. The process of purification will have to be worked out very carefully, otherwise the percentage losses would be very high. Taking its constituents in detail, however, the probability is that the substance will prove to be a valuable product. Tar acids to-day are, of course, at a high figure, but even after the war there will be a heavy demand for creosoting materials, and this constituent of the tar will therefore probably prove valuable. The light oils and middle oils of the tar would probably attain a fair price owing to the growing demand for petroleum products of all kinds. The value of the pitch is at present an unknown quantity. With its freedom from so-called free carbon and a constitution more nearly approaching oil pitch than coal-tar pitch, there seems to be every prospect of its finding a ready market. Taken altogether, the value of low-temperature tar would probably prove to be at least as high as that of high-temperature tar; it may easily be higher, but to be on the safe side a value of 2d. per gallon has been assumed, with a yield of 15 gallons per ton of coal carbonized.

Light spirit should prove an excellent motor spirit. A yield of 2 gallons a ton is assumed, and a value of 1s. per gallon.

Sulphate of ammonia.—The yield of this substance varies considerably with different coals, and rapidly rises after a temperature of 500° C. is passed. As far as the author's experience goes, the yield of ammonia at 500° C. is considerably lower than the 20 lb. to 30 lb. per ton of coal usually quoted, and a figure of only 10 lb. per ton of coal has therefore been taken for purposes of this estimate.

Gas.—The yield of gas at 500° C. is usually given at 5000 cubic feet per ton. This again is considerably higher than the quantity found by the author with most coals. Humic coals sometimes yield large quantities of gas at low temperatures, but this is often contaminated with high percentages of carbon dioxide. On the whole it is better to assume a gas yield sufficient to heat the oven, but insufficient to give any surplus.

On the basis of these assumptions the revenue side of the accounts gives the following figures :—

Receipts.	£
Coke, 63,000 tons at £1	63,000
Breeze, 9000 tons at 10s. ...	4,500
Tar, 1,350,000 gallons at 2d. ...	11,250
Light spirit, 180,000 galls. at 1s. ...	9,000
Sulphate of ammonia, 400 tons at £10 per ton	4,000
	£91,750

Profit per annum, £7,000.

The resulting profit can scarcely be described as startling, and it certainly does not attain the glowing dimensions generally promised in the initial prospectuses of companies interested in low temperature carbonization.

On the other hand the figures are distinctly conservative, and err probably on the low side. There is also ample room for improvement on both the debit and the credit sides of the account. Reduced labour and capital charges would make a great difference to the cost sheet. On the other side also there is ample scope for considerably improved figures. As far as the carbonization of bituminous coal is concerned, the author is not inclined to fix too high a value for the tar. The profits will be made primarily on the solid fuel; the Coalite process certainly showed that there was a demand for smokeless fuel, and if the country wants this fuel it will certainly pay for it. There is no reason also why the temperature should be limited to the 500° C. assumed in the above estimate. This figure has been selected because the solid residue at that temperature is a free-burning, easily ignitable product. But, under certain conditions, the carbonization temperature could be increased considerably beyond 500° and still leave an excellent fuel. The finest domestic fuel ever tested by the author had been carbonized at temperatures up to 800° C., and contained only 4% of volatile matter. The author is of opinion that the logical line of development in coal carbonization lies in the direction of a fractional distillation of the coal, the tars being extracted at a temperature sufficiently low to avoid the possibility of secondary reactions, and the temperature afterwards raised to drive off the ammonia and a large proportion of the gas. Such a procedure would not only increase the yield of by-products, but would result in a firmer and denser coke with a consequent considerably reduced proportion of breeze.

Lastly there is the question of the coal used. The estimate has been based on the use of high-grade small coal (an unwashed small coal fetching a pre-war price of 10s. per ton can certainly be considered a fairly good product). There are coals (like Yorkshire unwashed smudge, for example) which sold in pre-war days for considerably less than this figure, and in such cases low temperature carbonization offers a prospect of an excellent financial return."—Article by Edgar C. Evans, *Jour. Soc. Chem. Ind.*, July 31, 1918, pp. 217-8r. (A. W).

Note.—The article is well worth attention by coal owners in South Africa.

SOUTH AFRICAN GRASSES FOR PAPER MAKING.—"A large number of grasses from South Africa have recently been examined by the Imperial Institute, with the following results:—

No. 1.—Johnson grass.—Sorghum halepense.
No. 2.—Thatching grass (Dek gras). Andropogon Buchananii.
No. 3.—Tambookie grass.—Andropogon Dregeanus.
No. 4.—Tambookie grass.—Andropogon Auctus.
No. 5.—Tambookie grass.—Andropogon hirtiflorus

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	%	%	%	%	%
Moisture	10·3	10·1	9·2	9·1	8·7
Ash	7·4	6·3	4·5	7·1	3·8
SiO_2 in Ash ...	—	—	51·0	63·8	39·1
Cellulose ...	52·5	53·8	47·4	53·5	55·8

The samples were examined as paper making materials by treatment with varying quantities of caustic soda under conditions similar to those used in the production of paper pulp on a large scale, with the following results.

Yields of dry pulp expressed on grass as received

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
48%	50%	45%	47%	52%

The final reports in abstract are as follows:—

No. 1.—Shrinks greatly on drying, and does not bleach easily. Principal use would probably be locally for wrapping papers in, also possibly for special kinds of parchment papers.

No. 2.—Promising material for local manufacture, or conversion to 'half stuff' for export.

Nos. 3 and 4.—Yielded pulp of good quality, and good brown papers could be made from them by treatment with small amounts of caustic soda, and with larger amounts the pulps could be readily bleached and used for manufacture of white paper of good quality.

No. 5.—This grass would be quite suitable for the manufacture of paper pulp on a commercial scale."

—*Bulletin of the Imperial Institute*, Vol. xvi., No. 2, 1918, pp. 127-131. (J. A. W.)

SOME DEVELOPMENTS IN INDUSTRY DURING THE WAR.—"Mr. F. Kellaway, M.P., Parliamentary and Financial Secretary of the Ministry of Munitions, delivered an address on this subject at a meeting of the Industrial Reconstruction Council.

He confined his remarks to certain developments that had taken place in industry during the war. The war had revealed with pitiless accuracy the defects in our industrial equipment. Many of these defects had already been overcome, and the United Kingdom was now first in almost every sphere of industrial effort.

Germany, previous to the war, had established a predominant position in the electrical industry which would not have been possible without the supplies of mica brought from India and other parts of the British Empire. India produced 50% of the world's supply, and Canada 15%; Germany formerly produced 10% in German East Africa. But at the outbreak of war the mica market of the world was on the point of being transferred from London to Hamburg, thanks to the skill with which Germany had obtained a large measure of control of the Indian mines. Germany took 17,000 cwt. of the India mica in 1913, 50% of our total imports from India in that year being re-exported to Germany. Indian mica could now be exported to London only, and the mica in German East Africa was being worked and obtained by the Ministry of Munitions. The British electrical industry had taken the place previously held by Germany and Austria, and was now the first in the world.

The quantity of ferro-chrome produced in the United Kingdom prior to the war was practically negligible, but a plant had now been established at Newcastle sufficient to meet our requirements for many years to come, the power being obtained from waste gases from coke ovens, and the industry would compete successfully with the cheap water power of Scandinavia.

Australia had practically unlimited deposits of zinc ore. Germany obtained control of these, and imported from Australia a large portion of her supplies. The zinc concentrates now flowed from Australia to this country, and zinc smelters' plants were doubled, and in some cases trebled. The shipping position from Australia became so serious that all shipments of zinc ore from that quarter had to cease, but that difficulty should soon disappear, and the home production of spelter should reach 140,000 tons per annum, as against 32,000 tons before the war. The production of zinc oxides had also been encouraged, and on a war basis we were self-supporting.

We formerly depended upon Germany for our supplies of 30,000 tons of potash per annum, entirely from the Strassfurt mines. It had since been found that 50,000 tons of potash was going to waste every year in this country, in the dust or fumes from blast-furnace gases. The only known method of collecting those dusts was by the Halberg Beth system—a German invention. The design had been modified to ensure greater reliability and lower capital cost and to produce the quantity of steel which it was necessary to use. Plants in hand, including some without those modifications, should produce 18,000 tons of potash per annum. Gas-cleaning plants were being erected at two blast-furnace works, which should produce 1,600 tons per annum. Other sources of potash were being investigated, and we ought to be independent of foreign supplies in a comparatively short time. Germany had relied on her practical monopoly of natural deposits of potash in Europe to enable her to bargain for the recovery of her world market, but she would be disappointed.

The machine-tool industry was one that presented us with what looked like an almost insoluble problem at the beginning of the war, but the position had been met with astonishing success, having regard to the difficulties which the manufacturers had experienced in obtaining the necessary skilled labour. While we had never had as many machine tools as we could have utilised, our munitions supply had never been jeopardised thereby. The output in this country prior to the war was valued at £4,000,000 per annum. For 1917 the output was increased to £6,500,000, based on pre-war prices, or £10,000,000 at war prices. Specialisation had been so fully developed that it was highly probable the manufacturers would continue to specialise. Our output showed an increase of 66% in 1917 over pre-war production, compared with the German increase of 23%.

With regard to engineering methods, great advances had been made in the improvement of machinery, in accuracy of work, and in efficiency, which was the result of the necessity of organising for the production of interchangeable repetition work. In many shops the apparently fine limits

which we had required caused considerable dismay at the start, many old machines were found to be unsuitable for giving the accuracy which interchangeability necessitated, and fresh machines had been put down which were in every way more efficient. Increased efficiency of production had been secured by the increased use of milling machines, improvements in screw threads, development in drop stampings, and increased use and delicacy of gauges and die castings. All this had led to a realisation of the importance of having an up-to-date tool room, where the tools were made by men expert in that work, and the importance had also been realised of the use of 'gigs.' A great advance had also been made in shop transport. In addition to mechanical conveyors, there were also in universal use electrical trucks, with or without trailers, and platforms or skids on runners which could be lifted on low trucks on wheels and run to the desired position and deposited with their loads of work exactly where they were required.

As an instance of the importance of scientific knowledge as an aid to production, Mr. Kellaway mentioned the study which had been made of alloy steel giving high strengths which had allowed of its employment for aeronautical purposes, lightening the aeroplanes and allowing of better performance. The same held good to a certain extent of the light alloys employed for aircraft work. None of the other advances made in this war could be compared with that made on aeronautical work. Aircraft engines had not only become more powerful but their weight per horse-power had decreased to about one-third of what it was at the beginning of the war, and it was not too much to hope that before long the weight of the engine would be the same as the h.p. in lb.

Prior to the war the optical and scientific instrument industry in this country was in a lamentable condition, but our output had now increased twenty times, and we were self-supporting. Our pre-war output of optical glass was 10% of our requirements, 60% coming from Germany and Austria, and 30% from France. Our output was now in excess of that which could be absorbed in this country, and we must look to the development of foreign markets, which were previously the monopoly of Zeiss, of Jena, for disposing of the balance. Prior to the war the furnace-made scientific glass used in this country was, almost without exception, obtained from Germany and Austria. A few small firms here were capable of making a limited number of articles of lamp-blown scientific glassware, but beyond that our requirements were met by supplies originating in Germany and Austria. The turnover of our scientific glassware industry was now more than £600,000 per annum. Prior to the war the whole of the glasses for miners' safety lamps and oil-lamp chimneys were obtained from abroad, mainly from Germany and Austria, and 75% of the glass bulbs tubing and rod for electric lamps also came from Germany and Austria. The Home Office had to relax the stringent conditions with regard to quality and dimensions of glasses for miners' safety lamps. The Home Office came to the Ministry of Munitions for assistance, and they were now producing sufficient supplies of the right quality, and this country's output was sufficient to meet all our requirements. Before the war our output of bulbs for electric lamps was approximately 12 millions per annum, and three out of every four electric light bulbs in use in this country were imported, principally from Germany and Austria. We were now manufacturing sufficient to meet our essential needs."—F. KELLAWAY. *Iron and Coal Trades Review*, Dec. 6, 1918, p. 635. (J. A. W.)

Abstracts of Patent Applications.

635.18. Arnold Bradley. A continuous conveyor retort for distillation, carbonisation, wasting, etc., of coal, etc. 16.10.18.

This specification describes a continuously operating plant for low temperature carbonisation of coal or for roasting ores, comprising a conveyor of the endless-belt type travelling through horizontal or inclined retorts.

685.18. J. Nelson. Improvements in or relating to the temperature distillation of coal, shale and the like. 19.11.18.

The chief point claimed consists in subjecting carbonaceous material to the action of a hot current of vapourised hydro-carbons, oil gas, coal gas, carburetted water gas, or other like gas containing hydro-carbons with or without the admixture of super-heated steam at a temperature of 350—450 deg. C. The chamber in which the carbonaceous material is subjected to the hot vapour may or may not be externally heated. There are other minor modifications and combinations, but the principal feature is as set forth above.

704.18. Luckenbach Processes, Limited. Mineral selective and frothing agent and processes or methods of producing and using the same. 23.11.18.

This application relates to flotation concentration of ores, particularly to the use of selective flotative agents. It involves the use of a resinous substance as the mineral selective and frothing agent, such as copal, shellac and resin, or combination of these made by dissolving each in a suitable solvent; to these resins may also be added ammonia, oleic acid, petroleum, grease or tallow, providing the oil constituents are neutralized.

3.19. John Haigh Walker. Improvements in, or in connection with lifting or hauling gear. 6.1.19.

This is an application in respect of improvements in connection with the "Temperley transporter" type of transport haulage mechanism.

Changes of Address.

ANDERSON, R. C., *l/o* Modder B. G.M. Co.: Village Deep, Ltd., P.O. Box 1064, Johannesburg.

EDGAR, J., *l/o* Vaalhoek; P.O. Box 11, Pilgrims Rest.

JOHNS, J., *l/o* Millsite; Witwatersrand Deep, Ltd., P.O. Box 5, Knights.

MACER, L. W., *l/o* Brakpan; P.O. Box 41, Nigel.

MCDIVETT, D., *l/o* Bantjes Mine; Geldenhuis Deep, West Section, P.O. Box 54, Cleveland.

NEWHALL, P. M., *to* P.O. Box 1169, Johannesburg.

O'HARA, J. D., *l/o* City and Suburban; Geldenhuis Deep, Ltd., P.O. Box 54, Cleveland.

PARRY, C. S., *l/o* Randfontein; P.O. Box 46, Millsite.

WARRINER, R. C., *l/o* Crown Mines, Johannesburg; Room 2123, 120 Broadway, New York, U.S.A.

APR 1920

THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications

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Vol. XIX JUNE 1919. No. 12.

Proceedings

AT

23rd Annual General Meeting, June 28, 1919.

The Twenty-third Annual General Meeting of the Society was held in the South African School of Mines Building, Johannesburg, on Saturday, 28th June, 1919, Mr. H. S. Meyer (President) in the chair. There were also present :—

28 Members: Messrs. J. Gray, H. A. White, H. R. Adam, J. Chilton, C. J. Gray, J. R. Thurlow, G. A. Watermeyer, F. W. Watson, Dr. W. A. Caldecott, Prof. G. H. Stanley, J. E. Thomas, Prof. J. A. Wilkinson, G. Hildick-Smith (Members of Council), H. D. Bell, E. H. Croghan, J. E. Healey, L. D. Hingle, H. C. Hilton, A. King, C. A. Meiklejohn, P. T. Morrisby, S. Newton, J. J. R. Smythe, T. G. Trevor, J. T. Triggs, T. P. Waites, H. R. S. Wilkes.

3 Associates: Messrs. R. C. Anderson, J. A. Boyd, J. Gibson.

3 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 17th May, 1919, as recorded in the May *Journal* were confirmed.

ANNUAL REPORT OF COUNCIL.

The Secretary read the Annual Report as follows :—

The following Report is submitted by your Council upon the work of the Society for the past twelve months :—

Accounts.—It is gratifying to note an improvement in the financial statement put before you herewith. The receipts in nearly every item show an increase over that of last year, while the expenditure has been kept down as low as possible. The Finance Committee is therefore in a position to show a surplus on the year's working of £118 9s. 5d. The Society's *Journal* is somewhat less in size, but the increased cost of production, owing to higher wages and the greater cost of materials, has been more than counter-balanced by the increased revenue from advertisements. The cash assets show an increase of just on £100 over last year, while the amounts due to sundry debtors are more than covered by the sums recoverable from sundry creditors. Altogether the financial position is brighter than was anticipated at the beginning of the year.

While on the subject of finance, it is with the utmost regret that your Council learns that Mr. Littlejohn finds it impossible to continue to act as Hon. Treasurer—at all events for the coming year. He has occupied the position since June, 1902, 17 years in all, and has, during that period, given whole-hearted service to the affairs of the Society. The Council feels sure that the members will join with them in according him their most grateful thanks and in wishing him a very delightful holiday and change overseas.

Membership.—During the year sixteen Members, twelve Associates, and two Students have been elected or admitted, and twelve Members and six Associates have resigned. The losses by death have been again somewhat heavy, largely owing to the influenza epidemic, and your Council has to record with sincere regret, the deaths of the following :—

Members.—Capt. J. V. Harris, M.C. (Palestine), and Capt. C. K. Digby Jones (Russia), on active service, Messrs. S. H. Bright, J. M. Campbell, B. Palmer Carter (a previous Vice-President), J. S. Curtis, J. Ferguson, G. A. Lawson, D. J. Pepler and Q. J. Leitch.

Associates.—Messrs. M. S. E. Archibald, E. G. Baskett, J. I. Coppin, D. T. Leonard, D. W. Stacy, and G. F. Matthews.

Sir William Crookes, G.M., F.R.S., one of the oldest and most distinguished of our Hon. Members, also passed away on April 4th, at the age of 87.

	Jan 1895	June, 1896	June, 1897	June, 1898	June, 1899	June, 1902	June, 1903	June, 1904	June, 1905	June, 1906	June, 1907	June, 1908	June, 1909	June, 1910	June, 1911	June, 1912	June, 1913	June, 1914	June, 1915	June, 1916	June, 1917	June, 1918	June, 1919
Hon. Members	5	5	5	8	14	9	13	18	18	16	17	18	21	22	20	23	25	25	26	26	25	23	22
Life Members		1	1	1	1	1	1	2	3	4	7	7	8	9	9	9	10	10	10	9	9	9	9
Members	49	81	101	197	281	291	441	639	680	680	683	618	630	731	711	733	618	550	481	463	454	469	463
Associates	—	—	—	180	238	243	281	338	321	314	342	357	312	402	380	442	396	351	287	272	263	270	270
Students	—	—	—	—	—	—	—	4	8	4	7	18	20	60	57	22	21	15	2	3	5	2	2
	54	87	107	386	534	544	736	1,001	1,030	1,018	1,056	1,018	1,021	1,224	1,177	1,229	1,070	951	806	773	756	773	766

The total membership on the roll is now 766, a decrease of seven. With the conclusion of the war the position of a number of members, whose subscriptions are over two years in arrears, will have to be considered by the incoming Council. It is hoped that a greater interest will be displayed in the future by those engaged in scientific and technical occupations, and that every effort will be made to strengthen the membership of the Society and to further the objects for which it was formed.

Roll of Honour.—It is very difficult in the absence of information to complete our Roll of those who have been on active service. The Council would be grateful if every member who has been on active service or engaged in war work would supply the Secretary with the details of his service, in order that a complete Roll of Honour may be compiled, and eventually displayed as a record of the part played by the Society during the Great War.

Papers and Journal.—The standard of the papers read and discussed during the year under review, has been well maintained, and it is gratifying to see the interest displayed by the overseas technical journals, which reprint in full or lengthy abstract, practically every paper submitted. The following is the list of original papers and notes:—

July, 1918.—"The Effects of Dust Inhalation," by Dr. J. S. Haldane, F.R.S.

September 21st, 1918.—"Production of Pig Iron at Pretoria," by Prof. G. H. Stanley.

"Madagascar Graphite Production," by Mr. T. P. Waites.

The Presidential Address, by Mr. H. S. Meyer.

November 16th, 1918.—"Notes on the Footwall Beds of the Far East Rand Reef," by Mr. L. W. Macer.

"The Conservation of Materials (Launder Liners)," by Mr. F. Wartenweiler.

December, 1918.—"Determination of Available CaO in the Different Classes of Lime Supplied to Rand Reduction Works," by Mr. C. A. Meiklejohn.

"Report on Economies in Mining Engineering Supplies," by Mr. W. Elsdon Dew.

January, 1919.—"Application of the Theory of Probability in the Determination of Ore Reserves," by Mr. G. A. Watermeyer.

February 15th, 1919.—"Ancient Tin Mines of the Transvaal," by Mr. Max Baumann.

March 15th, 1919.—"The Handling of Amalgam from Steamed Plates," by Messrs. A. J. Herald and A. King.

"Chemical Engineering," by Prof. J. A. Wilkinson.

"Notes on Economies in Hand Drill Steel," by Mr. H. A. Read.

April 26th, 1919.—"'Safety First' in the Stamp Mill," by Mr. S. H. Steels.

REVENUE ACCOUNT for the year ended 31st May, 1919.

Dr.

1917-18. £ s. d.	EXPENDITURE.	1918-19. £ s. d.	£ s. d.
	To CHARGES (including Postages, Bank		
(62 12 3	,, Charges, Insurance, etc.) ...	61 9 9	
109 5 0	,, PRINTING AND STATIONERY ...	69 17 5	
19 17 3	,, RENT, LIGHTING AND TELEPHONE...	16 14 0	
596 0 0)	,, SALARIES	596 0 0	
787 14 6			744 1 2
(6 6 0)	,, GRANTS:—Prizes: School of Mines ..	7 7 0	
	,, Seymour Memorial Library .	25 0 0	
6 6 0			32 7 0
(22 8 6	,, TRANSACTIONS: Cost of binding, etc.	20 3 3	
16 6 0)	*Less* Sales	17 18 8	
6 2 6			2 4 7
	,, SOCIETY'S JOURNAL—		
(730 12 1	Cost of Reporting, Printing, etc.	690 10 3	
534 17 10)	*less* Received for Subs. and Advts. after deducting commissions on Advts. and Collections ..	655 12 3	
195 14 3			34 18 0
	,, Balance, being excess of Revenue over Expenditure for year ...		118 9 5
£995 17 3			£932 0 2

Cr.

1917-18. £ s. d.	REVENUE.	1918-19. £ s. d.	£ s. d.
	By SUBSCRIPTIONS—		
(543 18 0	Members, current year ...	550 4 0	
59 0 0	do. arrears collected ...	98 14 0	
193 1 6	Associates, current year ...	198 9 0	
32 12 0	do. arrears collected ...	49 16 0	
1 11 6)	Students	1 1 0	
830 3 0			898 4 0
27 6 0	,, ENTRANCE FEES		12 12 0
18 12 6	,, INTEREST ON FIXED DEPOSITS ...		18 14 4
0 6 9	,, EXCURSION ACCOUNT		2 9 10
119 9 0	*Balance, being excess of expenditure over revenue for year.*		
£995 17 3			£932 0 2

BALANCE SHEET, as at 31st May, 1919.

Dr.

1917-18 £ s. d.		1918-19. £ s. d.	£ s. d.
(148 15 0	To SUNDRY CREDITORS	160 16 0	
15 3 6	,, SUBSCRIPTIONS paid in advance ...	27 16 6	
39 19 0)	MINING EXHIBITION FUND ...	39 19 0	
203 17 6			228 11 6
	,, REVENUE AND EXPENDITURE ACCOUNT—		
(681 15 9	Balance at 31st May, 1918 ...	562 6 9	
119 9 0)	*Add* Excess of Revenue over Expenditure for year ending May 31st, 1919	118 9 5	
562 6 9			680 16 2
£766 4 3			£909 7 8

Cr.

1917-18 £ s. d.		1918-19. £ s. d.	£ s. d.
	By CASH AT STANDARD BANK—		
(168 6 2	Johannesburg	249 2 7	
14 10 1	London	34 2 0	
1 0 3)	,, *On Hand, Johannesburg*		
183 16 6			283 4 7
(405 13 4	,, Cash on Fixed Deposit with accrued Interest	405 13 4	
57 17 9)	,, Cash in Post Office Savings Bank with accrued interest.. ...	59 12 1	
463 11 1			465 5 5
45 0 0	,, OFFICE FURNITURE		45 0 0
73 16 8	,, SUNDRY DEBTORS		115 17 8
£766 4 3			£909 7 8

We have examined the above Balance Sheet and accompanying Revenue and Expenditure Account with the books and vouchers of the Society, and have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the affairs of the Society, according to the best of our information and the explanations given to us, and as shewn by the Books of the Society.

Sgd. ALEX. AIKENY..

(Signed) FRED. ROWLAND, *Secretary,*
Fellow Chartered Inst. Sanitarians.

"Agricultural Motor Tractors," by Mr. G. Hildick-Smith.

May 17th, 1919. "The Handling of Amalgam from Steamed Plates," by Mr. Percy Cazalet.

"A Safety Device for Exhausting Mercury Fumes during Steaming of Amalgam Plates," by Mr. J. F. Walker.

"Plate Steaming Box and Mercury Fume Extractor," by Mr. J. J. Smythe.

"Notes on the Closer Working and Joint Housing of Technical and Scientific Societies on the Rand," by Mr. Percy Cazalet.

"Notes on Defective Air in Disused Raises and Back Stopes," by Mr. C. J. Gray.

"A 'Safety First' Method for the Estimation of CO_2 in Mine Air," by Mr. H. R. S. Wilkes.

Grants.—Grants for prizes have been made to the evening class students at the S.A. School of Mines and Technology, and the customary donation given to the Seymour Memorial Library, which is largely used to great advantage by members of the Society. It is regrettable that a large number of books are missing from the library, but with the methods recently adopted an improvement in the working of the library may be anticipated.

Closer Working and Joint Housing of Technical Societies.—A further step has been made in this connection by the Joint Committee, which has submitted a concrete scheme for the housing of the scientific and technical societies located on the Rand, in a paper contributed by Mr. Percy Cazalet. At the meeting to-night certain resolutions will be placed before you, which if carried, will it is confidently hoped, help in the establishment of such a building. Unfortunately the societies, whose subscriptions are kept at a low figure in order to enable as many as possible to enjoy the benefits of membership, are not able to undertake the financial responsibility of launching such an undertaking. Although South Africa is not blessed with millionaires like the United States, where such facilities are provided, the Rand has been responsible for the wealth of a great many leaders of industry, and it is hoped that they, recognising the value of scientific and technical research may be induced to help forward the scheme by donating the necessary sum.

Visit to Works.—A most instructive and interesting visit was made in conjunction with the S.A. Institution of Engineers and the S.A. Institute of Electrical Engineers, to the New Modderfontein G.M. Co., Ltd., in January last.

Witwatersrand University. — At the February and May meetings certain resolutions were passed and forwarded to the Government in respect to the Government's action in refusing the Johannesburg Medical School to be extended, and urging greater facilities for higher education on the Rand. The Government has now agreed to the extension of the Medical School, and it is satisfactory to be able to state that a complete University training is now possible here in the Faculties of Arts, Science, Law, Commerce, Technology, and in the near future of Medicine. A complete solution of the problem of providing educational facilities for thousands of the children on the Reef still remains, as in respect to secondary education many are still compelled to go elsewhere, either to the Cape or overseas.

Council.—During the year nine meetings of the Council have been held as well as a number of meetings of the several Committees. The attendances at the Council, which averaged eleven, were as follows:—

H. S. Meyer	8	J. R. Thurlow[9]	6
J. Gray	9	F. Wartenweiler[10]	4
A. Whitby[1]	4	G. A. Watermeyer[11]	6
H. A. White[2]	8	F. W. Watson[12]	6
J. Littlejohn	2	John Watson[13]	1
H. R. Adam[3]	6	E. M. Weston[14]	3
J. Chilton[4]	6	W. R. Dowling	1
K. L. Graham[5]	1	G. H. Stanley	2
C. J. Gray[6]	6	J. E. Thomas[15]	3
C. H. Greathead[7]	6	J. A. Wilkinson	5
F. G. Macdonald[8]	1	G. Hildick-Smith	2
C. Toombs	5		

Leave of absence granted for: (1) five meetings; (2) one meeting; (3) two meetings; (4) one meeting; (5) six meetings; (6) two meetings; (7) one meeting: (8) Elected Sept., 1918, two meetings; (9) two meetings; (10) one meeting; (11) Elected Sept., 1918, (12) two meetings; (13) resigned Sept., 1918, (14) four meetings; (15) one meeting.

The Council regretted losing the services of Mr. John Watson, who left for India in October, and Mr. E. C. J. Meyer who found that pressure of business prevented him from giving attention to the work of the Society. Messrs. F. G. Macdonald and G. A. Watermeyer were elected to fill the vacancies thus caused. Mr. J. R. Thurlow was appointed a member of the Finance Committee, vice Mr. John Watson.

Owing to the influenza epidemic, it was decided, on the advice of the Medical Officer of Health, not to hold the monthly meeting in October.

Mining Exhibition.—The S.A. Institution of Engineers convened a joint meeting of representatives of the various societies to discuss the desirability of holding an Exhibition, mainly of articles and devices, etc., locally made, to meet the demand caused by the shortage of imports. Owing to the

lack of sufficient financial guarantees, the matter was dropped, and your Council has decided to hold the Society's Fourth Mining Exhibition, as soon as possible after the declaration of peace.

The thanks of the Council, as of the members, must be here recorded to the members of the several Committees and to your Hon. Auditors for many services rendered.

Mr. Rowland, your indefatigable Secretary, still carries out the duties of the office to the utmost satisfaction of the Council and members, and our thanks are especially due to him.

In closing this report the Council completes its year of office at the time when the Great War has come to an end by the declaration of peace. It will however, be many months before normal conditions return. Many of the difficulties created by the war will remain, and will need much wise statemanship before they are finally overcome. The industry with which most of us are connected, is confronted with many such difficulties, and their solution requires the careful consideration and judicious action of us all, as upon their satisfactory solution depends not only the livelihood of the majority of our members, but also the well-being of the Witwatersrand, while the State itself is directly and seriously concerned.

It is hoped that the Society will, in the future, as in the past, take a worthy part in improving the technique of and stimulating economy in the mining industry. With the growth of other industries the field of work and usefulness for the Society is ever expanding.

The President: In rising to move the adoption of the Annual Report and Accounts I should like to make a few comments on the past year's activities of the Society. The papers submitted have been of great variety and of a generally high standard, and they have been representative of the three technical branches of science from which the title of the Society is taken. The notes under the heading of general business have been of a practical nature and have been much appreciated. The attendances at meetings have shown some improvement, but have scarcely been commensurate with the quality of the papers, nor of the active discussions that have taken place on them. The industry has passed through an extremely trying period, and the feeling of uncertainty engendered by such conditions cannot have failed to have had a detrimental effect on the quality of the work done. I do not propose here to discuss the causes which have given rise to this manifest feeling of unrest, they have been so ably and frequently set forth during the last few months that all should be thoroughly familiar with them. The fact remains that we as members of this Society are intimately concerned; unemployment must be staring many in the face, and unless something is done immediately to obtain some assistance, whether it be of a nature to afford direct financial relief or it be in the form of a modification of the stringency of the Mining Regulations, or both—a calamity will fall on these fields. The recently appointed Commission will no doubt elucidate a great deal of valuable and important information on the conduct of this industry. It may make recommendations of a far-reaching nature, but it is nevertheless clear to me that this investigation must take much time, and it is to be fervently hoped that the diagnosis and subsequent treatment recommended will not be applied too late to cure a patient already *in extremis*. Personally, I can only repeat the suggestion made in my Presidential Address a year ago, namely, that there is nothing to prevent all employees of this industry doing their share by giving fully of their best instead of only a portion.

Although the membership shows no increase, it has nevertheless been strengthened by the qualifications and attainments of those who have been elected during the year. The losses from war and disease have been great, and on behalf of the Society I record its regret and sympathy with the bereaved relatives.

A serious loss to the Society—fortunately not due to the causes given above—is the resignation of Mr. Littlejohn as Honorary Treasurer. This position he has occupied to the complete satisfaction and advantage of the Society for 17 years. He now leaves on a well-earned holiday to join his only son, who has served with gallantry and distinction in the War. Such signal service given ungrudgingly to this Society for a number of years cannot be passed without proper expression of the Society's gratitude, and I shall later formally move that a Hon. Life Membership of this Society be conferred on Mr. Littlejohn.

On behalf of the Society I offer its hearty congratulations to the following: Our Secretary, Mr. Fred Rowland, whose staunch and

unselfish work for the Red Cross has earned for him the distinction of O.B.E.; a similar honour has been conferred on Mrs. Cullen, wife of our Past-President. Professor Orr, in recognition of the great work he has done in furthering the interests of soldiers disabled by war, has been awarded the same distinction. Dr. Moir, by virtue of his extensive research work, has fittingly been the recipient of the South African medal and grant from the S.A. Association for the Advancement of Science.

Taking everything into consideration I think that members will agree that the Society has during the past year fully upheld its traditions.

I believe that Peace is signed. (Loud applause.) This must be a matter of intense relief to everybody and a matter for infinite congratulation. As far as it directly concerns us, it removes, to some extent, an excuse. We shall now, I hope, have affairs straightened out as quickly as possible, and we can then devote ourselves wholeheartedly to our business once more.

It is very difficult for me suddenly to express the feelings of members of this Society on such an occasion. Perhaps the one who seconds the adoption of the Report can more fittingly deal with it. With those few remarks, I beg to move the adoption of the Report of the Council for the year.

Mr. James Gray *(Vice-President):* Mr. President and gentlemen, I have much pleasure in seconding the adoption of the Annual Report and Financial Statement. As you will observe from the report before you, it has been a year of steady progress. It is a matter for congratulation that we have been able to hold the Society together during the past four and a half years.

The announcement regarding the signing of Peace must give us all a great feeling of relief, and I certainly do not feel any more capable than Mr. Meyer in expressing our feelings on such an occasion. I think we all feel the matter too deeply, and I am sure we hope that it will be, to quote the Scriptures, "a Peace which passeth all understanding."

Mr. T. P. Waites *(Member):* Under the heading of "Council" the various attendances of sundry members are given. I think it would help some of us, seeing that reflections have been made on the attendances at meetings of mining and other members, if, when the nomination papers are sent out, the number of attendances of Members of Council are given; it would be some guidance to some of us who notice here that several members have attended but one meeting and others two, in making some difference in our nominations.

The Secretary: I am sorry I omitted to put at the foot of this table that a number of members, for various reasons, were granted leave of absence owing to inability to attend. This will be inserted in the *Journal*.

The President: You will notice that a number of the attendances refer to Past-Presidents. There is no obligation on them whatsoever to attend, but you will notice that they still show a keen interest. Some of the Council have been in Europe, others have been ill—in fact, to give a detailed explanation of the reasons for attendance or non-attendance right away down this list is hardly worth while this evening; we have too much other business.

The Report and Accounts have been placed before the meeting and formally moved and seconded. Are they approved?

Adopted *nem. con.*

The President: The next business is the declaration of the result of the ballot for Officers and Council for the ensuing year.

The Secretary: The following is the report of the Scrutineers:—

Johannesburg,
28th June, 1919.

The Chairman,
Annual General Meeting,
Chemical, Metallurgical and Mining Society of South Africa,
Johannesburg.

Dear Sir,

We report that we have received 77 envelopes containing Ballot papers, and as a result of our scrutiny, we declare the following to have been elected:

President.—Mr. James Gray.

Vice-Presidents.—Messrs. J. Chilton, G. A. Watermeyer, and A. Whitby (unopposed).

Hon. Treasurer.—Mr. J. R. Thurlow (unopposed).

Members of Council.—(Unopposed).—Messrs. H. R. Adam, R. A. Cooper, C. J. Gray, C. H. Greathead, H. C. Hilton, J. H. Johnson, A. King, J. J. R. Smythe, F. W. Watson, F. Wartenweiler, E. M. Weston, H. A. White.

Yours faithfully,
(Sgd.) S. NEWTON,
P. T. MORRISBY,
Scrutineers.

Mr. Jas. Gray: I have to thank you for the honour you have conferred on me in electing me President of our Society. I can

assure you that I deeply appreciate the honour, and I will do my best to maintain the high traditions of the Society. It is no light task to follow in the footsteps of my illustrious predecessors in office, but I hope, with the help of the able office-bearers and Council you have also elected, that next year we shall be able to say that at least we have had a successful year. It is fifteen years ago to-night since I attended my first meeting of the Chemical, Metallurgical and Mining Society, and I little thought that the effluxion of time would see me occupying the Presidential Chair.

I would like to propose a very hearty vote of thanks to the scrutineers for their duties.

The President: The Society, I am sure, is to be congratulated on the selection of its new President, who, if he has the same support from the Council that I have had during my year of office, need have no fear of carrying the Society through a successful year.

There are two additions to the Vice-Presidents; they are both men who have always taken a very keen and active interest in the affairs of the Society.

As regards the unopposed dozen Members of Council, they are a very well mixed and able collection—(laughter)—and on that account nobody cared to stand against them. So I must congratulate the Society on the whole of its officials for the coming year.

I should like to make, at this stage, a formal proposition—without repeating it again, it is this— that, in view of his past services in the interests of the Society, Mr. Littlejohn be elected an Honorary Life Member. (Applause.)

Mr. G. Hildick-Smith *(Past-President)*: I would like to second that.

The President: I hardly need put it to the meeting; I take it that it is carried unanimously. Agreed.

NEW MEMBERS.

Messrs. H. C. Hilton and S. Newton were appointed scrutineers. After their scrutiny of the ballot papers the following gentlemen were declared unanimously elected:—

BARRETT, HENRY ECCLES, P.O. Box 1072, Johannesburg. Assistant Inspector of Mines.

HILL, WILLIAM ROBERTSON, Robinson G.M. Co., Ltd., P.O. Box 1024, Johannesburg. Surveyor.

FROW, H., S.A. School of Mines and Technology, P.O. Box 1176, Johannesburg. Mining Engineer.

SMITH, WATSON, Ph.D. (Zurich), Cape Explosives Works, Somerset West, C.P. Acting Chief Chemist.

SWINBURNE, UMBEVILLE FERGY, Rand Club, Johannesburg. Chief Inspector of Mines, Union of S.A.

The Secretary: The following gentleman has been admitted an Associate by the Council:

GRIFFITH, STANLEY VINCENT, School of Metalliferous Mining, Camborne, Cornwall, England. Mining Student.

HON. AUDITORS.

The President: I beg formally to move that Messrs. Alex. Aiken & Carter be re-elected Honorary Auditors for the coming year, and at the same time to express a hearty vote of thanks to them for their good offices during the past year.

Prof. J. A. Wilkinson seconded. Agreed.

GENERAL BUSINESS.

THE PRICE OF GOLD.

Mr. G. Hildick-Smith *(Past-President)*: There is a paragraph in the *Star* this evening which is most interesting. It is in regard to the price of gold. I do not know whether any of you have seen it; if not, I will read it. The cable is dated London, June 23rd:—

> "The *Times* states that the Government has conceded the principle that the gold producers are entitled to the best price obtainable in the world's best market. It refers to the difficult details of the problem and issues a warning against the expectation of an immediate solution."

The first part of the paragraph is just what we want, and the quicker we can have it the better. But, from the second part, it would seem that it will take a little time to arrange matters.

The President: And find the best market.

Mr. G. Hildick-Smith: In various part of the world the price paid for gold is to-day from 5 to 40 above the price we are obtaining.

The President: Mr. Smith's remarks are very interesting, and I hope something satisfactory will come out of it.

THE HANDLING OF AMALGAM FROM STEAMED PLATES.

Mr. Chas. Hurlbatt *(Member)* (contributed from Rhodesia): I was very interested in reading the discussion in the last issue of the *Journal* on the question of plate steaming. I think Mr. Cazalet has hit the right nail on the head with his very pertinent remark to the effect that the best way to avoid the danger or inconvenience to men engaged in this work is not to do it. My own experience—a matter of about 15 years of mill work in various parts of the world—is that the steaming of plates is entirely unnecessary. I think I can say for myself that my experience covers a fairly wide range, having milled ores from 4 oz. —in Western Australia—down to about 3 dwt., and in no single case have I found steaming necessary. A plate does not require to be more than just "set," and though a good skin of amalgam no doubt makes a very nice Christmas present for the company, I heartily agree with the contention that plates are not a bank, and the bank is the proper place for such gold. The keeping of a plate in a merely "nicely set" condition is as simple a matter as it can possibly be, and I am of opinion that the keeping of more amalgam on plates than is absolutely necessary is bad policy, in that there is always the liability of theft and it entails quite needless work in steaming, necessitating the payment of overtime to men specially brought on shift for this work or taking the current shiftsmen from routine work, for which they are required, or would not be employed, and at the same time exposing these men to needless risk. Mr. Cazalet gave the names of two mines where steaming had never been done, except to prove—in these cases I take it—the absence of accumulated gold on the plates. I am afraid I must differ slightly from him in the case of the Ferreira Deep. I was employed in that mill, soon after I first came to South Africa, under the late Mr. Pepler, and there it fell to my lot to take part in what I was given to understand was the annual steam, which took place about Christmas time, if I remember rightly. This was, I think, in 1906. However, there was no such practice in force as a regular monthly or quarterly steam, so for the purpose of Mr. Cazalet's contention that steaming is not a necessity, his statement is about correct. I have heard arguments advanced that steaming does a plate good. I hold that a plate should never be allowed to get into such a loaded condition as to require "good" of that kind being done to it. There is also the point that if the millman is expected to come out square with assay office returns he must have no accumulation on his plates after the month end. If he has, it can only mean a shortage on his call, or that the call itself is incorrect. The case thus boils down to one of, either keeping plates free of accumulation or, steaming monthly. The answers to the questions as to which procedure is more economical, safer, and more convenient in every way seems to me obvious. That Rand authorities are becoming alive to the question of the advisability of steaming is of very great interest to me, as I have had many an argument on the subject, and have always held that the practice is not only obsolete, but entirely unnecessary, and could never understand why it was persisted in practically throughout the Rand.

SAFETY FIRST IN THE STAMP MILL.

Mr. Chas. Hurlbatt: The safety device for stamp chairs is no doubt very efficient, but the addition of more parts to watch and keep in order is to my mind rather a step in the wrong direction. The goal to be aimed at is to eliminate causes of trouble, in this case the slipping out—or round—of the chair. Putting back the jack shaft an inch or so overcomes this slipping out, a statement I can vouch for, as I had this done some three years ago and have had no trouble since. A remark made about keeping the chain cap in good order is very much to the point; a cap that is not firm and true is almost bound to cause trouble by the chain twisting, and more than likely an accident will result.

In connection with the "Safety First" discussion, may I add one other point, and that is in connection with the use of chain slings for stem and other heavy work. A chain sling does not show its weakness—or at any rate not markedly—till it breaks, whereas a wire rope sling at once gives warning by a broken strand and can be discarded before an accident results, and old wire slings originally used for heavy stem work can be used up with complete safety for shifting smaller parts, such as heads, tappets, etc. Furthermore, for heavy work a wire rope sling is very much less cumbersome to handle and adjust than a chain, and is much less liable to slip.

NOTES ON THE CLOSER WORKING AND JOINT HOUSING OF TECHNICAL AND SCIENTIFIC SOCIETIES ON THE RAND.

By Percy Cazalet (Member).

(Printed in Journal, May, 1919.)

The President: I shall now ask Professor Wilkinson to move the various resolutions submitted by Mr. Cazalet in the paper read at the May meeting on the question of "Closer Working and Joint Housing of Technical and Scientific Societies on the Rand." The subject will then, after being formally moved, be open to discussion and a resolution taken. I may say that, unfortunately, Mr. Cazalet has been very ill recently, and is just beginning to recover again. I am sure nothing would have given him greater pleasure than to have been here this evening to hear these resolutions moved.

Prof. J. A. Wilkinson: Nothing would have given me greater pleasure than that Mr. Cazalet should have moved these resolutions, for the simple reason he has taken so much interest in the matter ever since the commencement, about four years ago.

The scheme for the housing of the local scientific societies read by Mr. Cazalet at the last meeting of this Society deserves the careful attention of every member. It is not a whim of the moment, but the work of the Committee during the last four years, in which period much labour has been undertaken in order to bring it to its present stage. That the idea is by no means new is shown by the appendices, which give members some notions of what has actually been achieved elsewhere, and in this connection the following excerpts from the *Journal* of the Society of Chemical Industry, January 31st, 1919, page 18R, may also be found of interest:—

"Not only is there much overlapping and duplication of effort, especially in the matter of publications, but no machinery existed whereby the collective and considered opinion of all workers in chemistry could be made fully operative, either constructively or in defence of privileges and interests; moreover, there was no means by which the advice of the body in general could be taken and tendered for public purposes, the result being that limited and incompatible views were not infrequently expressed when enquiries were made by official bodies.

"The need of securing the co-operation of the various agencies now in existence was brought prominently under notice by the President of the Chemical Society in his address to the Fellows in April last. Impressed by the necessity of taking time by the forelock, he soon afterwards took the further step of calling together a few of these who were specially concerned in forwarding the advance of chemical interests to discuss a scheme of federation, with the result that it was resolved that action be taken forthwith to secure the formation of a Federal Council with certain defined aims and objects. It was agreed that the ultimate aim should be the establishment of a Federation of all the bodies specially interested in the development and application of chemical science. In such an association the constituent bodies representative of particular interests should maintain their individuality and each be the organ of its proper branch of activity; but they would unite in considering all matters of concern to the general body, as well as in supporting the publications of the Federation and in maintaining a house where all meetings could be held and the official staff find accommodation, together with a complete library.

"A necessary feature of the enterprise would be the foundation of a Club open to all members of the Federation who were prepared to pay the Club dues. A precedent for the Federation of chemical interests in the manner outlined is afforded by the Royal Society of Medicine, established in 1907, in which are incorporated all the various societies—to the number of 20—concerned with the development of the science of medicine, but excluding the colleges which have professional interests in their charge. This society publishes proceedings, in which the work of the several sections is recorded, but with distinct pagination, so that the publication of each section may be issued or bound separately. Each section of the society is represented on the Council of the Society by its President. The Royal Society of Medicine has its quarters in a large building in Wimpole Street, constructed at a cost of £50,000. Originally it was proposed to afford Club accommodation on a story at the top of the building; from motives of economy this proposal was not carried into effect; it is now much regretted that such was the decision. The scheme was communicated in broad outline to the various bodies more or less closely

concerned, with a request that they would appoint delegates to a Council, which might seriously take the matter into consideration.

"As the result of the deliberations of the delegates appointed by the various bodies, a Federal Council has recently been constituted, which is composed of nominees to the corporate societies covering all aspects of pure and applied chemistry, the purpose of the Council being to take such action as will ensure the adequate appreciation of the due claims of chemical science. The steps to be taken towards establishing an Association or Guild of Chemical Societies and the provision of a house for the accommodation of such a body have already engaged the attention of the Council, and a committee has been appointed to deal with these problems."

In the absence of Mr. Cazalet, I have much pleasure in formally moving these resolutions in the name of this Society:—

That this Society (1) Is desirous of securing in Johannesburg a joint house with such other technical and scientific societies as have an appreciable proportion of their members resident on the Rand.

The President: Excuse me, Professor Wilkinson. Do you think it is the wish of the meeting that we should take these resolutions one at a time, or *en bloc*?

Prof. G. H. Stanley *(Past-President):* One at a time.

The President: Does that burke discussion on the matter?

Prof. J. A. Wilkinson: I am entirely in the hands of the meeting.

The President: Or shall we narrow it down to one or two resolutions for discussion?

Prof. J. A. Wilkinson: There is only one, the financial one, which Professor Stanley has in his mind, the third one, where there would be probably any real discussion; and therefore, if it is the wish of the members present, I will take them seriatim.

The President: I merely make that suggestion so as to get a little more expedition and despatch about it. Just to test the feeling of the meeting, I move that these resolutions be taken one at a time.

Mr. H. R. S. Wilkes *(Member):* To resolution No. 3, which I had an opportunity of hearing discussed five nights ago, there appears to be some objection, and a very serious one. Perhaps it would be better to take resolutions Nos. (1), (2) and (3), and then the others can be taken *en bloc*.

The President: Well, I think we will fall back on the original scheme; Professor Wilkinson will read the six resolutions, and we will deal with them afterwards separately. Agreed.

Prof. J. A. Wilkinson: The first resolution I have already read out. The second resolution says:—"Agrees to pay in an annual sum, either based on a *per capita* or other scale to be agreed, to a Trust Fund, the money so raised to go towards the cost of providing such joint institute."

(3) Further undertakes, if legally possible, to loan at interest any capital sums which it is, or may become possessed of from time to time, to such joint institute for its legitimate purposes.

(4). Hereby appoints two members with power to act in conjunction with representatives of other participating societies as a joint committee towards the desired end; including appealing for funds, drafting a constitution, fixing the basis of contributions, and, if these are approved by individual societies, securing land and buildings for permanent or temporary quarters, and generally to be responsible for the bringing to fruition of the scheme for the joint housing of technical and scientific societies on the Rand.

5. Agrees that the joint committee shall be empowered to receive and deal with suggestions put forward by any of the participating scientific and technical societies through their nominated representatives.

(6) Agrees to the inclusion of the following societies, or so many of them as may jointly or severally agree to take part in the scheme as participating societies, namely:

S.A. Institution of Engineers,
Chemical, Metallurgical and Mining Society of South Africa.
S.A. Institute of Electrical Engineers.
Association of Transvaal Architects.
Institute of Land Surveyors of the Transvaal.
S.A. Association of Analytical Chemists.
Geographical Society of South Africa.
Geological Society of South Africa.
S.A. Association for the Advancement of Science.
Astronomical Society.
S.A. Society of Civil Engineers.
Royal Society of South Africa.
Institution of Mining and Metallurgy (Local Branch).

In accordance with the President's ruling I now propose Resolution No. (1).

Mr. G. Hildick-Smith (*Past-President*): I will second that.

The President: I do not suggest there can be any amendments. Is there any discussion? This meeting is intended to give members an opportunity of expressing their views on these resolutions, and any suggestions they may make will be duly noted; but I do not think we can take any amendments: either this thing goes through, or it does not go through; any amendments can only be in the nature of suggestions, if you decide to definitely turn down any particular resolution. You see, this is merely an expression of views of this particular Society, and you have got to take this, or leave it, so to speak, and submit any other suggestions you can make, but you cannot rule anything to the contrary.

Prof. J. A. Wilkinson: I hope there will be some discussion. I have acted as your representative for some considerable time on this Committee, at the request of the Council, and I hope whomsoever you will send to this Committee will be able to state briefly that the members in General Meeting assembled also showed enthusiasm in this respect.

The President: There being no further comments, and as Resolution No. (1) has been formally proposed and seconded, I will now put it to the meeting. Declared carried.

Prof. J. A. Wilkinson: I now move the second resolution.

The President: If you get a joint house you must be prepared to support it: I think that is what it means.

Mr. G. Hildick-Smith: I second that resolution.

Mr. C. J. Gray (*Member of Council*): Does not it simply say that the amount is to be one that is agreed upon? I take it that that agreement will come up for consideration at some future date. Therefore the motion can be passed without any question.

The President: I think all it asks for is an expression of willingness.

It has been moved and seconded that Resolution No. (2) be passed. It is one on which there should be no possible misunderstanding. Declared carried.

Prof. J. A. Wilkinson: Resolution No. (3) is the contentious one. I beg to move it, for the purpose of discussion, and I hope somebody will second it, even if we amend it afterwards. It reads that—

(3) "This Society further undertakes, if legally possible, to loan at interest any capital sums which it may from time to time, to such joint institute for its legitimate purposes."

In the balance sheet which has been brought forward this evening you will see the cash on fixed deposit and accrued interest amounts to £400 odd; the cash in the Post Office is a sum of, with accrued interest, £59 12s. 1d.; that is, roughly speaking, a sum of £460 that this Society has in the bank against a rainy day. Now, what this particular resolution says is this: "Lend us the money, take a first mortgage on the building; we will give you a percentage on it." But suppose, for example, this Society intends, and, of its own accord, desires at some future date to have some moneys at its disposal for some particular object that it desires to push forward: If the money is lent to the joint house then it may not be possible to get it at a moment's notice, and the Society may require to make other financial arrangements for the time being, on the strength of the mortgage bond for the loan to the Committee of the joint house. That is the real objection to this; and, of course, if you like to amend it, it is within your power to do so.

The President: In other words, we have to say that we are quite prepared to take everything for nothing, to never back our own interests with a farthing; that is about what it amounts to!

Mr. J. E. Thomas (*Past-President*): Might I ask how often we have had to touch our sums on fixed deposit, say, in the last six years?

The Secretary: Not once.

Mr. J. E. Thomas: I beg to second the adoption of the third Resolution.

Prof. G. H. Stanley: I would like to support this resolution if the means at the disposal of one of the societies in Johannesburg were really material in connection with this housing scheme. The scheme proposed, I think, is estimated to cost something like £110,000. We have about £450; it is absolutely negligible in that connection; on the other hand, we are prepared, I take it, in

terms of the second resolution, I put up a small but loyal list of our members for the selection. On the other hand, again, we do expect a fair working capital before we have anything. If that be put, then it is merely a question of the opinion of the ruling chiefs of the Society.

The President: With us, Mr. Thomas remarked just now, it required an answer to his question, that nothing has been put down. And I have no doubt in my mind that the Council, or whatever the proper body may be, would be a sympathetic one. I suppose we could present names, if we do it we would be in a position to select.

Mr. G. Hildick-Smith: I should like to know the exact period of time this third person is in the work.

The Secretary: Twelve months, at 4[illegible]

Prof. J. A. Wilkinson: There is one amendment in regard to what Prof. Stanley has said. The scheme as proposed calls for a sum of £[illegible] and the idea has been to try, if possible, to raise £[illegible] of that sum, from some third source. Now, if a group of societies makes such a request surely they must be able to say, "We cannot do enough, but we are prepared to do our fair share." That is the point, and therefore, if we can say, even with one small sum of £[illegible], "We will put up all we have for the time being; and we are prepared to put that up if the other is obtained," then that seems the least we are prepared to bring forward in the face of our policy. If other societies are prepared to put their contribution, then, at the same time, we should be prepared to do our share towards it, because it is a good investment and that we are not going to lose it.

Mr. C. J. Gray: I am prepared to support the proposal on very much the same lines that I took with regard to the previous one—that is, by an increase in principle, to the business side of the money. I do not think we are bound definitely by agreement that we shall put in every penny if we decide, at the time, the final scheme is agreed upon that are various details which will have to be agreed upon at that time.

The President: I think Mr. Gray puts it very clearly. The idea is simply to enable us to show our goodwill to do everything we possibly can. We have the money, and the details are a matter for the future. The point, this is the most practical form resolution—to my mind it is the least—and therefore it should be thoroughly considered, rather than passed in a hurry. Has any other member any further observations to make on it?

There being no further comment, the resolution was put to the meeting and declared carried unanimously.

The President: I think gentlemen it will have a very considerable influence when it is known that this particular resolution has been carried unanimously by this Society.

Prof. J. A. Wilkinson: I now move the fourth resolution.

Mr. Jas. Gray: I second the resolution, and in doing so, I desire to propose that Mr. H. S. Meyer and Prof. J. A. Wilkinson be appointed the representatives of this Society. In doing so, I need only say that Prof. Wilkinson and Mr. Meyer have been connected with the Sub-Committee since the inception of the scheme of closer union, and they are particularly *au fait* with everything in connection with it, and I have no doubt that they will be able to do everything possible with regard to the matter.

Mr. G. A. Watermeyer (*Member of Council*): I will second the nomination of these two gentlemen. I am quite certain that we could not do better.

The President: The first resolution is that two members be appointed in the terms that Professor Wilkinson has just now read. Do you agree to the general terms of the resolution? Agreed.

The President: And to the nomination of your two representatives? Agreed.

Prof. J. A. Wilkinson: I now move the fifth and sixth resolutions.

Mr. H. R. Adam (*Member of Council*): I second that. Agreed.

DETERMINATION OF AVAILABLE CaO IN THE DIFFERENT CLASSES OF LIME SUPPLIED TO RAND REDUCTION WORKS.

By C. A. Mehlhejohn (Member).

(*Printed in Journal, December, 1918.*)

REPLY TO DISCUSSION.

Mr. C. A. Mehlhejohn (*Member*): The determination of available CaO is a subject that has been often discussed, and one on which so much work has been done that

it required considerable temerity before reintroducing the same in a technical society. The main object in doing so was to bring forward what appeared to the author to be some shortcomings in the standard method.

Mr. Jas. Gray is of the opinion that the author's conclusions are based on insufficient evidence, and is apparently of the belief that strict accordance with the Standard Method will give the best results. With this I do not agree. The results given in the original paper are only typical of many experiments carried out, and it was only after considerable work had been done that the modified method described was adopted. In the author's opinion the modification—particularly with regard to the fine grinding, length of time of agitation and settling overnight before titrating—has been fully justified.

Mr. Gray states that it is well known that standing overnight before titrating tends to give low results. This may be so, but our investigations showed that practically identical results were obtained whether the solution was filtered and titrated direct, or when the same was allowed to stand overnight before titrating. While agreeing with Mr. Gray that proper standardization of the acid is one of the essential details in the analysis, it is hard to think that any chemist would use an acid for this purpose which had not been properly standardized.

With Mr. Watson's remarks I am in complete agreement. The method described by him as being in use at the Consolidated Gold Fields laboratory is, with the exception of small differences of manipulation, practically the same as that described by the author, and is all the more welcome as corroborative evidence that the Standard Method is not all that is to be desired.

THE APPLICATION OF THE THEORY OF PROBABILITY IN THE DETERMINATION OF ORE RESERVES

By G. A. Watermeyer (Member of Council).

(Printed in Journal, January, 1919.)

DISCUSSION.

Mr. J. S. Olver (*Visitor*): I have been in close touch with sampling on the Rand for the past sixteen years, and have made an attempt to improve sampling practice and to establish higher standards of accuracy in a number of mines in various parts of the Rand; but I agree with Mr. Watermeyer that the results secured from sampling are still in many instances far from satisfactory. I therefore welcome any revival of interest in a subject which I consider to be one of the most important factors in the successful working of the Rand banket. But a careful consideration of Mr. Watermeyer's system and a close study, extending over several months, of the results obtained on one of the mines in which it is being tried have convinced me that this system, if adopted, will do much more harm than good.

Mr. Watermeyer's view of the common methods of sampling may be illustrated by a single quotation. After referring to predictions of value based on conventional practice, modified by certain methods of adjustment, he says: "The results of the predictions, all will agree, are not commensurate with the time and money spent on the sampling and assaying. Experience has shown that predictions determined on the arithmetic mean of the samples are invariably in excess of the mill return. One is led to the conclusion that the arithmetic mean of the sampling results is not the most probable mean. We shall have to go farther and see whether there is not some law governing the distribution of values which will enable us to arrive at a much closer valuation than has heretofore been possible." Is not the conclusion expressed here an unwarranted inference? The fact—which I admit—that the mean is in most instances too high does not necessarily show that the method of "meaning" is wrong. It might also be due to the improper taking and handling of the individual samples, and I believe that this is in fact the true explanation.

I wrote a paper on sampling eleven years ago for the then-existing Transvaal Institute of Mine Surveyors, and the paper was republished in "Faults and Dykes" (1911). My view of the results obtainable by methods which involved the use of the arithmetic mean may be expressed in the following quotations:—(1) "The mistakes which are to be feared are those which are the result of a personal bias in one direction. The law of averages is always on the side of the intelligent and careful sampler, since it in time tends to eliminate all accidental errors, but it does not help the man who

works on wrong principles. The personal bias of an untrained sampler is almost invariably in the direction of excess in value." (2) "The author is convinced by results obtained in several mines, by other samplers as well as by himself, that, leaving the error in the estimation of stoping width out of the question, the actual sampling can be done with a probable error of 5% . . . it is assumed that the samples from which the average is obtained are sufficiently numerous to eliminate the effect of accidental errors."

"Now, this degree of accuracy is more than sufficient for all practical purposes. If the exact value of the reef exposed in the drives and winzes around a single block were known, it is likely that this result, as an estimate of the value of the block, would have a probable error in the neighbourhood of 15% or 20%, while the actual error would in some cases be far greater than that. Again, every estimate of milling grade calculated from development values must be made upon an assumed stoping width and on an anticipated percentage of sorting, and the probable error of these together would certainly not be less than 5%. The author therefore holds that it is waste of time to try to reach a maximum probable error of less than 5%."

Writing after a greatly extended experience, I maintain that these quotations from my paper give a good working idea of the standard of accuracy which should be demanded in the valuation of the average unoxidized ore of the Rand. Now, if an approximation to this standard can be maintained in practice by means of the simple methods advocated in my previous paper, it is evident that the elaborate system suggested by Mr. Watermeyer is unnecessary. But I shall try to prove that the later system is unsound, and that, if generally adopted, it will prove positively harmful by lowering permanently the standard of work done by samplers on the Rand.

Mr. Watermeyer's frequency curves were obtained by taking all the recorded section-values in stopes over twelve months and noting the frequency of values between certain intervals. This was probably the correct procedure for obtaining a curve for application to stoping values, but ought not another curve to be made for the correction of development values? The stope values would practically all be taken from payable blocks, while half the development sections might well be in unpayable ground. The frequency of high values would be much greater in the stopes. I imagine that, if two curves were used, some curious contradictions would be found, but the two curves appear to me to be a logical development of the system. But, however that may be, either of the curves must be erected upon actual sampling results, and must absorb and perpetuate all the defects of the past sampling. It is difficult to see how a curve based on the indifferent sampling of the previous year can be relied upon to correct the indifferent sampling of the present year.

I should like to ask Mr. Watermeyer this question: If the curve were based, say, on a thousand section-values, and these sections were all recalculated with the help of the curve, would not the adjusted average value be exactly as before? If so, his system has merely reproduced the arithmetic mean, which he had dismissed as wrong. The only claim left would then be, presumably, that the individual blocks or stope faces are more correctly valued. It would, in any case, be very hard to accept the accuracy of the individual factors when the total was admittedly wrong, but, apart from that, I think it can be proved conclusively that the system fails woefully to justify this remaining claim.

Let us make a few calculations, using the table provided for the West Rand Consolidated Battery Reef. Let us suppose that ten sections were taken in a stope, and that nine of them each returned the average value of the mine, say 475 inch-dwt., while the tenth returned 75 inch-dwt. The value of the face, calculated by ordinary methods, would be 10·25 dwt. over 42 in. By the new system the value works out at 9·85 dwt. Now let us suppose that the nine sections in this stope had yielded 1,475 inch-dwt. each—not at all an unusual average for this mine—while the tenth remained at 75 inch-dwt. The ordinary valuation would then have been 31·78 dwt. and the adjusted value 3·08. It will be seen that a single low value in ten sections has in this case reduced the average from 31 dwt. to 3 dwt. —surely far too great an influence for a single sample, even though one could be certain that it was correctly taken on the right reef and that no mistake had occurred in the subsequent handling of the sample. I wonder how many mine managers would allow this stope to be stopped as unpayable? Yet this ought to be done if the system is accepted. But that is not all. A trebling of the value of nine out of the ten sections

has actually reduced the value of the stope to less than one-third of the former value obtained by the same system!

The above is a hypothetical case, but I could show a very similar case from the actual sampling of the Battery section. Here are some actual cases:—

(*a*) Six sections taken in a stope gave the following values over a stoping width: 2, 28, 42, 75, 210 and 300 dwt., giving an average of 96 dwt. over 37 in. The adjusted value was 4·1 dwt. In the course of three months 16 sections have been taken in this stope, and they have averaged 105 dwt. over 38 in., while the lowest average for any of the months was 96 dwt. In a mine of this sort the frequency table ought to go up to at least 8,000 inch-dwt. (the average for 16 sections was about 4,000 inch-dwt., while eight of them returned over 2,500 inch-dwt. each), and, if such a table had been used, the adjusted value would no doubt have been a good deal lower than 4·1 dwt. But that figure is sufficiently absurd.

(*b*) Thirteen sections taken during two months in a stope gave an average of 57·5 dwt. over 53 inches. Nine of the sections returned over 1,500 dwt. each. The adjusted average was 9·58 dwt.—much too severe a reduction. If the inch-dwt. from three of the sections had been adjusted down to 4,000 each, the average would still have been 44·3 dwt. The valuation for the preceding month was 30·32 dwt. (unadjusted), and six out of eight sections in that month each went over 26 dwt., so that the increase during the next two months was not very extravagant.

(*c*) A curious feature of Mr. Watermeyer's system is brought out by the figures for one of the two months, which were taken together in example (*b*). In that month eight sections gave an average of 68·2 dwt. The lowest was 13 dwt., and the next lowest 28·8 dwt. The adjusted average was 12·8 dwt., *i.e.*, lower than the lowest actual section.

(*d*) Six sections gave an average of 37·3 dwt. over 56 in. If the inch-dwt. of the richest section had been cut down to those of the next richest, the average would still have been 25·56 dwt. The adjusted average was 4·1 dwt.

(*e*) To show that such freakish results are not confined to the Battery Reef, I will give an instance from the Main Reef Section of the West Rand Consolidated. Seven sections in a stope gave an average of 20·1 dwt. over 41 in. Five consecutive monthly samplings (two preceding and two succeeding the one under consideration) gave an average of 15·1 dwt. over 37 in. This value of 20·1 dwt. was adjusted down to 5·5 dwt. In the portion of the property from which this instance was drawn the ore reserves show a high assay value, but a very low percentage of payability. If adjustments such as this were accepted as correct, the only possible recourse would be to close down the shaft concerned. I append the details of the seven sections, and I think most experienced samplers will agree, after examining them, that a severe reduction of values in such a case is inadmissible, the more so when the history of the stope is considered. I give the sampling channels, with the sample widths, and (in brackets) the assays:—

(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)	(*g*)
8 (5)	10 (5)	8 (7)	10 (27)	10 (45)	12 (14)	10 (20)
	11 (16)	8 (11)	10 (7)	10 (52)	12 (52)	12 (27)
			10 (4)	10 (95)	12 (25)	12 (126)

I have recently met with a case in another mine where in a part of a stope the values might have been expressed in percentages, like those of tin or copper. In this case a table going up to about 50,000 inch-dwt. would have been required. Now, suppose that five sections had been taken in the rich area and one just outside it, and that the latter had returned 150 inch-dwt. The value of the stope would then have been adjusted to unpayability. It may be that according to the law of probabilities, these rich zones might not to exist, but the fact is that they do, and samplers are concerned, not with what ought to be, but with what is.

Another defect of the new system is that it makes no allowance for great changes in stoping width. Supposing, as might easily be the case in the Battery Series, it were decided to increase the width of a stope to, say, 200 inches, in order to bring in the hanging-wall reefs. If the stope is to remain payable it must now return at least a thousand inch-dwt. per section, and some sections would probably go a good deal higher. The weight of such high values in the table is very low, and a single poor section would so far outweigh the others that the stope would be returned as unpayable.

It seems evident that there is something wrong with a system which produces results such as those quoted above. Against these must be set the figures given by Mr. Water-

meyer. With a single exception the monthly estimates quoted by him show a satisfactory agreement with the recovery value, but that does not by any means prove that the system is correct. I have no doubt at all that the explanation of the agreement is that the actual sampling has given too high results, and that the new system—on account of the reduced influence of high values and the exaggerated influence of low values—tends to make a heavy reduction in the general average. An equally good agreement could be got much more easily by applying a sampling factor. Even if it could be proved that the system gave the true average value of the ore, its use would never be justified so long as it returned individual results so glaringly wrong as those quoted above. That they are wrong will not, I am sure, be doubted for an instant by anyone qualified to give an opinion on the nature of the ore in the areas from which the examples were drawn.

The main purposes of mine sampling are (1) to give as nearly as possible the value of each block and of each stope face, in order that it may be decided whether the block or face is payable, and (2) to value each band of reef separately as a preliminary to deciding upon the most profitable stoping-width. Each block or stope and each band of reef has to be considered separately and judged on its own merits, apart from any law of probability. I think I have given instances enough to show that the new system does not attain the first of those objects, while it does not even attempt to influence the second.

The system is an interesting essay in mathematics, but I believe it to be based on a misconception of the nature of the gold deposits of the Rand. The more these are studied the clearer it becomes that the Main Reef Series is characterized throughout by zones or shoots of high, medium and low grade ore. The range between the payable medium-grade ore and the high-grade ore is often very large and the change from one to another of the three grades is sometimes very abrupt. A zone of either grade may be of almost any size, but it will seldom be found that a uniform value extends over the whole area of a mine of average size on the Rand. Further, though sharp fluctuations may be found in the value of consecutive sections within a zone, the average of, say, seven or eight such sections will usually conform fairly closely to the average grade of the zone. We find, then, a fair uniformity within the zones, but marked contrasts between the values of contiguous areas in the same mine. Anyone who has a wide knowledge of the reefs of the Rand could point to many instances where in one area of a mine the probability of finding, say, 400 inch-dwt. in any section might be about 70%, while in another area it might be no more than 2%. It is evident, then, that a frequency table based on sections taken throughout that mine would be wrong if applied to either of the areas referred to.

But that is not all. The above remarks refer to zones within a single pay-horizon. There are six known potential pay-horizons on the Rand. It is very rarely that they are all payable in the same area, but three or four of them commonly show payable areas in a single mine. Each of these has peculiarities with regard to the quantity and distribution of its gold, and a frequency table prepared indiscriminately from all of them would probably not be applicable to any one of them. Further, all these horizons may fall within a possible stoping width, and this condition, as pointed out above, introduces a further complication—the factor of stoping width.

In order to apply the law of probabilities properly it would be necessary to construct a table for each zone in each separate reef, or, where more than one reef could be carried in a stope, for an area of composite reef. But then the system would become entirely impracticable.

I believe that in nearly every mine where good profits have been returned those profits have been nearly all won from a comparatively small proportion of high-grade ore. The bulk of the ore crushed on the Rand returns little or no direct profit, though it helps to reduce the cost of mining the high-grade ore. In such circumstances any system which, as this system undoubtedly does when indiscriminately applied, cuts down severely the high values must so far reduce the value of the ore reserves as to leave very little inducement to carry out a bold policy of development. This consideration applies especially to the case of a reef, such as the South Reef Leader or the Main Reef Footwall Leader, which exhibits high values with a low percentage of payability. Where the bulk of the ore in a mine is supplied by another reef with comparatively low but even grade, and a frequency table based mainly on the values

in the latter reef is applied to the rich zones in the patchy reef, those zones are likely to be adjusted down to a grade which would not justify the cost of locating and exploiting the isolated zones.

Apart from considerations of accuracy, any system which involves unnecessarily laborious calculation should be discouraged. It takes up time which would be much more usefully employed by the samplers in investigation underground or on the surface, in studying the plans and records, in supervising the crushing of samples, in panning, or in discussing with other officials matters relating to their mutual work

One of the most serious dangers of the system, to my mind, is that it will almost inevitably lower the standard of efficiency of sampling. A conscientious sampler will give especial care to the taking and measuring of a sample which is likely to give a high value; but, when he sees the influence of such values repeatedly reduced to vanishing point, he will almost inevitably become less careful. A man whose values are frequently adjusted in the manner illustrated above is apt to say to himself that sampling has become a farce, and will thus lose interest in his work; or, if he has faith in the system, he will come to rely upon it to correct deficiencies in his work. In either case that work is almost certain to deteriorate. But perhaps the most dangerous feature in Mr. Watermeyer's paper, if it be accepted, is his statement that a large error of excess is inherent in ordinary mine sampling on the Rand. If the theory of inherent error be once generally accepted, it will be almost impossible to bring about any material improvement in sampling practice, and I am firmly convinced that the only way to improve sampling results is to improve sampling practice.

I believe that the common excess over the mill-yield-plus-pulp value is mainly due to the following causes: (1) The tendency to take samples where the reef is best defined; (2) the tendency to take into a sample too great a weight of the richer part of the reef; (3) over-estimation of the sample width; (4) under-estimation of the stope width, (5) salting during the crushing of samples; (6) unavoidable mining of waste rock in faulted ground; (7) unauthorized sending of unpayable rock to the mill. To these might be added in certain instances the over-estimation of percentage sorted, of tonnage crushed, and of recovery percentage.

The first ten of those causes are within the control of the sampler. The fifth sometimes is not, but *always ought to be*. I have recently been told, on what should be unquestionable authority, of a case in which the salting of samples made a large unpayable section of a mine appear for a long time to be decidedly payable. I consider it most important that the crushing of samples be done under the direct supervision of the sampler. Where this is done he can retain complete control of the samples, not merely until they are sent to the assay office, but, by a simple system of keeping duplicates of the samples sent in, until the assay values have been returned to him and accepted by him as correct.

I have been asked to suggest a method of adjustment to put in place of Mr. Watermeyer's method. Personally, I would lay down no hard and fast rule. I think that adjustment is very rarely necessary where sampling practice is good, and that a competent chief sampler with a good knowledge of his mine should be qualified to judge when and to what extent adjustment is called for. When a sudden departure, in either direction, from the usual is met with in development, the result should always be checked by resampling. Where three, or even two, unusually high values follow each other in a stope, I should take their mutual confirmation to be sufficient—provided always that I was satisfied that the values represented a correct return from the samples as taken underground—and should let them stand. A single exceptionally high section in a stope might be averaged with its two neighbours, and the average substituted for the high value. Where an occasional high value makes the difference between payability and unpayability in a stope, the whole face should be resampled at short intervals; and, if isolated high values occur, they should be accepted. It must be remembered that very low values are just as likely to be wrong as very high ones. The range is greater in the latter case, but in the long run the errors on one side ought to balance the errors on the other.

A practice which is sometimes used is to set a maximum of 1,000 inch-dwt. per section, but I consider this practice entirely inadmissible. Take the case of a very wide stope. In a 25 ft. stope the highest value that could be got in any section would be 3·33 dwt. This is an

extreme case, but the wider the stope the less is the latitude allowed by this method. Again, take the case mentioned above where the average of sixteen sections was 4,000 inch-dwt. This rule would bring the average down to about 800 inch-dwt., and I am sure that this reduction would be altogether unjustifiable. I have carefully examined the position in this instance, and I should only reduce the value of one section —from 18,000 inch-dwt. to 8,000, the average value of the three next highest sections. This represents a reduction of 21 on the 16 sections. On the other hand, a limit of 1,000 inch-dwt. would be far too high for application to poor areas.

The great objection to all detailed adjustments is that they tend to cover up the defects in the sampling. If the sampling is bad, it is far better that the management should know it.

As to applying a constant percentage reduction, it may be absolutely necessary to do this in valuing the ore reserves where the standard of sampling is not high, but this adjustment is a very poor substitute for high-class sampling. The trouble with indifferent work is that the error is not constant, and that where, say, a 30% reduction gives a fairly correct average for the whole of the ore reserves, a 10% reduction might have been sufficient for a block containing a certain class of reef, while a 50% reduction might not have been too much for a block containing a different type of reef.

It cannot be too strongly insisted upon that sampling is not an exact science, and that one is almost entirely dependent upon the honesty and judgment of the sampler. If the chief sampler cannot be relied upon to do the adjustment honestly, he should be got rid of at once; and if his judgment is not to be relied upon in this respect, I should not allow him to make any adjustment whatever without superior authority. In any case, adjustment should be very sparingly used, and every instance should be conspicuously marked in the records, both the original and the adjusted value being recorded.

I am more and more convinced that serious, but usually undetected, losses are taking place on many mines on the Rand through the neglect of sampling and of that study of reefs for which sampling is the best possible school. I have no hesitation in saying that the average underground official is not well equipped for the work of identifying, tracing and locating reefs and the detection of faults; and the chief sampler, if he is the right man in the right place, should be given the final responsibility in these matters.

I believe that the accepted principles of sampling are perfectly sound, but that they are often improperly applied. The remedy is to make a bold advance on the following lines: (1) To improve the general pay and status of samplers, and thus attract educated and intelligent men into this branch; (2) to give the budding sampler a thorough grounding in the principles and practice of his art, and to impress on him the importance and possibilities of the work; (3) to select the most promising juniors and give them the opportunity of familiarizing themselves with the reefs and with the vagaries of gold deposition in a variety of mines; (4) to encourage them to make a thorough study of their work, offering them as an inducement the early prospect of well-paid and responsible positions. I meet many chief samplers, keen and otherwise good men, whose usefulness has been limited by the lack of a diversified experience of sampling and a wide knowledge of the reefs.

I believe that many mines would benefit largely if they placed the chief sampler—or rather the expert who might be evolved from the present chief sampler—in an advisory position parallel to the executive position of the underground manager. He might be called the "Mine Valuer," and might in the largest mines be relieved of the direct supervision of the sampling; but in any case I cannot too strongly insist that, if his work is to be properly done, he will have to spend underground the morning of nearly every working day. It is futile to attempt to conduct such work from an office, though a close study of plans and records is an essential part of the work.

REPLY TO DISCUSSION

Mr. G. A. Watermeyer *(Member of Council):* Lord Kelvin once remarked: "When you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."

In the paper laid before you last January I endeavoured to construct a scale of experience by which one could measure and express in numbers all one's previous

experience in forming an opinion of what would be likely to occur in immediately succeeding circumstances. It seems that in the opinion of the majority of my critics I have succeeded indifferently well. Most of those who took part in the discussion seemed to be under the impression that I was endeavouring to introduce a system of calculation which would improve bad observations. No such claim was made. My object is to obtain the best results from the data laid before me. The importance of this point is such that I shall probably reiterate it, consequently I must claim your indulgence when it recurs.

An important omission on my part is drawn attention to by Sir Robert Kotze. He considers that a hiatus exists between the method of the construction of the curve and the reason for its application. It is a point which worried me when initially considering the matter, and the problem arose, in how far would it be justifiable to use past experience in future estimates, and, if so, could this experience be reduced to figures. Having plotted the experience polygon, and fitted the smooth probability curve to it, the obvious application was the use of the ordinates as weights in obtaining a weighted mean. Where, as in valuation a few facts are known, and the vast majority unknown, the simple mean of known facts is not by any means the most probable value of the whole, known and unknown. By taking advantage of a few thousand known facts we may, if they show a tendency to follow a determinable law, prove that a very definite relation, within limits, exists between the frequency of any value taken at random and the deviation of this value from that of maximum frequency.

In order that the simple arithmetic mean may represent the most probable value of the whole, known and unknown, it must satisfy the following conditions:—

1. It must be the most frequent value.
2. The number of deviations therefrom above and below should be the same.
3. Large deviations should be less frequent than small deviations.

A study of either of the curves represented will show that the first two conditions are not satisfied. In no instance have I found these conditions satisfied. The simple mean occurs in a position where the variation in frequency is close to its maximum. The most frequent value is in general too low to supply the need of a probable mean. Some value between the simple mean and most frequent value is necessary to maintain the balance between value and frequency. Weighting values by probable frequency and dividing the sum of the products by the sum of the frequencies, a probable value is obtained which seems the most reasonable value to represent the whole. The use of the second moment is not unique in this respect. Not only is it used in the method of least squares, but also in determining the radius of gyration in mechanics. Insurance tables are constructed on similar lines. The proportional frequency in a very large sample of the population is taken as the probability of individuals of different ages surviving.

A sample premises that one is unacquainted with the value of the whole, and that the object is to determine this value without being in a position to measure it directly. One must not take the sample as a fact which applies rigidly to the whole. The value of a sample is very probably the value of five pounds or so of rock taken down by the sampler, but one cannot logically conclude without further investigation that it is the actual value of about 200 tons above it. Value per ton does not necessarily imply that you have one or more tons of the material. By taking the simple arithmetic mean one infers all the above. By observing the proportion of occurrences of a given value in a large number of cases it is reasonable to infer that this value will persist to the same extent in a large sample taken to the mill. Hence the proportionate frequency may be used as a weight in order to obtain the probable value of the whole. With regard to the reliance one may place on the weighted mean, it depends largely on the number of section values employed in the construction of the curve and the deviation of the individual observed frequencies from the frequencies as given by the curve. In illustration of this I show two curves from the same reef. The first represents the result of 1,800 values employed in the first instance, and the second the result of 360 subsequent values. The dotted lines on each side of the curve are the loci of the probable deviation of the observed from the theoretical frequencies. By probable deviation I mean that it is an even chance that the frequency of any value taken at random will fall within or without the area embraced by the dotted lines, in other words, that the chance is even that the

deviation of the observed from the theoretical frequency will exceed or fall short of the length measured parallel to the Y axis between the curve and the dotted line on either side of the curve. This probable deviation varies inversely as the square root of the total number of observations.

Perhaps Mr. H. A. White will pardon me if I express my gratitude for the entertainment which the perusal of his contribution

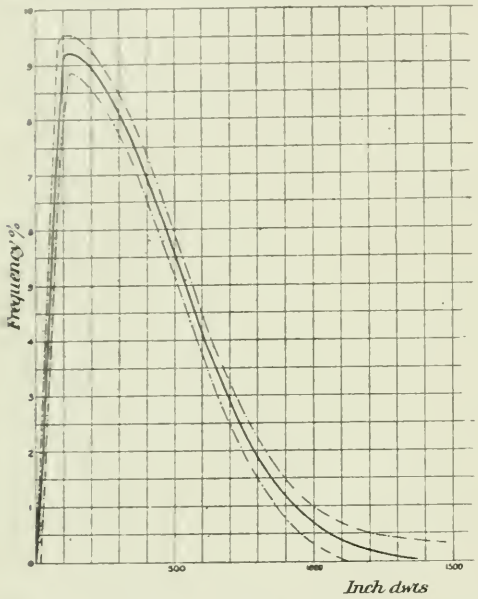

Fig. 1.—Probable deviation calculated on 1,800 sections.

afforded me. He first rated me for the bad fit of the curves to the observations, exposed my logical lapses, ruthlessly rent the mathematical camouflage in which I was enveloped, and finally pointed out the numerous errors which I had carelessly left unswept in the stopes and drives in transmitting the ore from the mine to the mill. I was very much relieved to find in the end that very little harm had actually been done to the mine. My endeavour was to calculate the value of the ore delivered at the mill from the heterogeneous sources in the mine. He has failed to grasp the elementary idea of probability which is measured by the frequency with which events are associated with one another.

Mr. H. R. Adam questions the justification for the application of the theory of probability to sampling. The theory of probability is based chiefly on sampling. The object of sampling is to obtain the probable value of the whole. He assumes that I am unaware of constant errors and requires a detailed discussion of each individual source. I am not disputing their existence, but fail to see why a logically weighted mean value should be replaced by an illogical simple mean merely because the latter is more easily calculated. He asks whether it follows that a skew frequency curve results from neglecting constant errors. The skew frequency curve is absolutely the most solid fact resulting from my

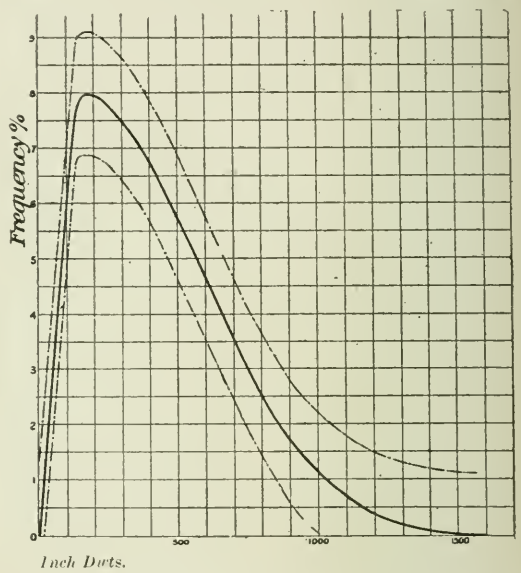

Fig. 2.—Probable deviation calculated on 360 sections.

investigations. It is not dependent upon constant or any other form of errors. It is simply the result of smoothing out the irregular polygons obtained from experience. Investigations were made in ten different cases and the two illustrated were the least symmetrical. The causes of skewness consist in the far larger number of low-valued sections being encountered than the high-valued sections. If he wishes the percentage of black balls drawn in the example given he may obtain them by reversing the scale of the abscissæ.

Mr. Hingle finds the discrepancy due almost entirely to causes which have nothing to do with averaging. He enunciates these causes in detail, and establishes the fact that the samplers on the reef are unable to measure a stope width. If samplers are not competent to measure stope widths, why not relieve them of this function and calculate the widths in the office. He states that the sampler's average inch-dwt.

may be quite correct, but his dwt. per ton will be too high. Hence the reason for my adoption of the inch-dwt. scale. Look after the gold and let the tons look after themselves. The latter frequently emanate from places which do not contain gold, and then the sampler is blamed for his inability to measure widths. He enumerates a large number of sources of error due to causes the effects of which he is unable to gauge, and then objects to any allowance being made therefor on the only logical method possible. He remarks, "Now, unless the samples taken during the year have been spread uniformly over rich and poor stopes his curve of frequency will not represent the most probable weight to be placed on individual samples." This may be so, but it is far more probable than any other.

Mr. Gibson has given us a very interesting description of the way he deals with section values in stopes. It certainly shows the positions in which the various samples have been taken and the individual results, but I do not think it gets him much closer to the probable value of the whole. He employs several similes to show that the weighted mean is incorrect. The consideration of every individual in a crowd would give the average height definitely, but if you were only in a position to measure, say, ten out of each thousand, it does not follow that the average of the ten would be the average of the thousand. Similarly, if we wished to know something about the Transvaal and the only data at our disposal were the area and value of a few isolated farms, if we knew the total number of farms we should certainly be in a better position to estimate the total area and probable value than if we had no data at all. The table he gives is very interesting as far as it goes, but its value would have been enhanced had he given all the values instead of stopping short at 400 inch-dwt. The tonnage derived from his particular stope is a very small proportion of the total going to the mill, and though its value would be of great importance if we were milling from that stope alone, the relative importance is very much diminished when mixed with ore of a hundred more or less other stopes, good, bad and indifferent.

Mr. Clarence imputes statements to me which would be very difficult to find in the original paper. I have not assumed that the discrepancy between the mill yield and that predicted from the mine sampling is due entirely to the effect of abnormally high values. What I maintain is that hitherto we have omitted to make allowance for the very important factor of probability. He has given us some marvellously close agreements between the estimated and actual recovery on a number of mines, but has omitted to state what methods of estimation and comparison were employed. He takes exception to the statement that the mechanical work of meaning differs very little from previous custom. I have had no complaints from the surveyors and samplers using the tables that they are unable to complete their work without overtime. If he would like to know the reason why all sample sections should be taken into account when constructing the curve, it is because those entrusted with the mining of ore do not stop immediately a stope face shows unpayable values, but continue in the hope that the value will improve, and the proportion of low values becomes greater than it would have been if all values in unprofitable areas had been excluded. As he surmises, I do not discriminate between varying reef widths and values because the reduction works are not particular as to whether an ounce of gold comes from a three or a fifty inch reef.

Mr. Payne also imagines that my intentions are to bolster up bad sampling and assaying. As previously mentioned, the object is to obtain the most probable result from the data under consideration.

Mr. G. M. Clark has appreciated the points which I have endeavoured to make, and amplified them.

Mr. Olver has forwarded his contribution somewhat late, but I shall endeavour to meet his objections. He agrees that the simple mean is in most cases too high, but puts it down to improper taking and handling of individual samples. If samples are not taken properly no method of meaning will give a correct result, but very definite evidence is required to prove that the samples have not been taken properly. He quotes from his published book on "Faults and Dykes" certain didactic remarks on errors of sampling. He uses the term "law of averages" without definition. The sound thereof seems to please him. He states that the personal bias of the untrained sampler is almost invariably in the direction of excess in value. How has he divined this? He is convinced that the actual sampling can be done with a probable error of 5%.

How has he determined this? If he knew the definition of the word "probable error" he would not fall into the blunder of being able to take individual samples with a probable error of 5 , and then in the next breath state that the mean of his individual samples gives a block value with a probable error in the neighbourhood of 15 or 20 . If he were acquainted with the meaning and determination of probable errors he would know that the probable error of a mean varies inversely as the square root of the number of individuals. His experience cannot have stood him in very good stead if he still maintains the above statements and his ideas on the standard of accuracy cannot be relied upon. He misinterprets the object of these curves. No claim has been made that they will make indifferent sampling good, but that the intelligent use of them will give results more probable than any other method of interpretation. If the curve were based, say, on a thousand section values and the mean of these sections recalculated with the help of the curve, the adjusted average would not be as before, and consequently his inference falls to the ground. He proceeds to make a few calculations. When he keeps within reasonable limits of experience he finds the reduction from the simple mean in the neighbourhood of 0·4 dwt. by weighting. When he arrives at the limits of experience he finds a marvellous reduction. His statement "if this stope has yielded nine samples of 1,475 inch-dwt—*not at all an unusual average for this mine*"—is so loose that I might almost term it *suggestio falsi*. The facts do not justify the assertion in italics. During the years 1917 and 1918, 2,950 sections were sampled on the Battery Reef in this mine; of these, six lay within the limits of 1,450 to 1,500 inch-dwt., 66 exceeded 1,500 inch-dwt., and 2,878 were below 1,450 inch-dwt. The 66 sections mentioned were distributed between the limits 1,500 and 10,224 inch-dwt. The chance of values over 1,500 inch-dwt. persisting is consequently very small, and it would be dangerous to assume that the average content of the face would lean more nearly to the 1,475 inch-dwt. value than to the 75 inch-dwt. value. He has taken several sections showing freakish results as representative sections of the reef. That is where he loses all sense of proportion. He seems to think that the curve is a bit of conjuring of the imagination, whereas it is a picture of the frequencies with which the values have occurred and may be reasonably expected to persist. He facetiously remarks that according to the law of probabilities these rich zones should not exist, but the fact is they do, etc. This is exactly where the danger comes in. When such rich zones occur it does not follow that the rest of the mine will be closed down and work concentrated on that rich zone for the very sound reason that the manager knows it is a mere incident and must not be allowed to upset his sense of proportion.

The following table gives the results over a period of six months for each of the mines except the Van Ryn, which is calculated over a period of eleven months. The mill-yield-plus-pulp is expressed as a percentage of the mine valuation:—

Van Ryn	98·3
New Goch	87·9
Meyer and Charlton ...	97·6
Aurora West	100·1
Roodepoort United ...	98·2
West Rand Consolidated ...	93·2

ANCIENT TIN MINES OF THE TRANSVAAL.

By Max Baumann (Member).

(Printed in Journal, February, 1919.)

DISCUSSION.

The President: I understand Mr. Trevor has been kind enough to come from Pretoria to give us a contribution to this paper.

Mr. T. G. Trevor *(Member)*: In a paper, which I read before the Society on this subject in 1912, I stated that "I hoped this paper might act as a nucleus around which the information collected by other observers may gather until sufficient evidence is collected to form a fair basis from which to reason as to the origin and date of the workings and the race of the workers." Mr. Baumann's paper is a very valuable addition to this evidence, as he has been enabled to give the details of ancient work about which I could only generalize. I note with pleasure that he has come to the same conclusion which I did, that the ancient tin mines in the Rooiberg area could not have accounted for less than 2,000 or 3,000 tons of tin. I still hold, however, that we have not yet accumulated sufficient evidence to form a fair basis for reasoning as to the origin and date of the workings or

of the race of the workers, and I submit the following observations made since my original paper was written, with the object of adding to the evidence available rather than with the intention of joining in any discussion which I think premature as to the controversial points at issue.

I.—Historical References:

I have gone through all the records of missionary travel available in the Pretoria Public Library, and find the following references, which throw some light on the question of the metals in use amongst the natives before the white occupation of the country, and hence on "ancient workings":

A.—*Campbell.*—Campbell was the first white man to leave a record of his journeys north of the Orange River. He visited Kuruman and the north-western districts of the Transvaal (Marico) in 1813. On page 225 of the journal of his first journey he mentions: "The people here, Lattakoo, obtain copper and iron from some nations behind them. It is understood that there are copper mountains not very far distant, but it is probable that these metals come from Europe through Portuguese Settlements."

On page 393: "The Matchipies get their copper rings through the Wanketzanese, the next nation to the north. These are not made by them, but by a nation to the east of them nearer the Indian Ocean."

On page 297: "The Maquenas beyond the Magalalizone, from whom the former obtained clothing and beads of European manufacture."

In the journal of his second journey, undertaken some years later, in which he visited Kurachane, which lay on the head waters of the Notowane about 20 miles west of the present town of Zeerust, on what is now known as Moilo's Location, and which was the great centre of native civilisation in the country, the following references occur:—

(*a*) On page 165, Vol. I.—"Meribohwhey, six days' wagon journey, N.E. of Lattakoo, saw native wearing piece of metal resembling silver in the shape of a heart, also four rings of the same metal. It might have come from a nation of white men beyond them."

(*b*) Page 228 mentions smelting of iron and copper, but not of tin.

(*c*) Page 245 mentions iron hammers.

(*d*) Page 270 mentions metals much resembling gold and what appears to be silver rings.

(*e*) Page 227 mentions bags of copper beads.

(*f*) Page 276: List of articles made in Kurachane, but no mention of tin or bronze, though iron and copper have special mention.

B.—Moffat.—Moffat visited the same country about ten years afterwards (1830), but in the meantime Kurachane had been entirely destroyed. I am informed that the inhabitants were the Baroutsie, whose descendants are now living on Moilo's (Kalafeins) Locations.

Page 467: Moffat describes a smith making *brass* out of copper and tin.

Page 584: "The Baconi country (apparently the country to the east of the Marico) also yields tin. The mines I did not see, but the specimens of moturu, as it is called, which I purchased from the natives, were of the very best quality."

There are no other references to tin which I can find.

C.—Baynes, 1887.—Rooiberg Mountains called Marikele.

D.—Chapman's Travels, 1868.—Mountains to the west of Rooiberg marked as copper mountains on map.

E.—Diary of Louis Trichardt, 1837.—No mention made of tin except the following:—

Extract from "Dagboek van Louis Trigardt, Monday, 22nd May, 1837, Dorps River, Zoutpansberg, Transvaal:

"Old Botha and Albach shortened tyre of Albach's wagon wheel. After eating, old Botha smelted* copper for bullets. Old Strydom came and told us that the crucible melted but not the copper. He made three bullets, but more tin than copper. Carclus and Albach tried to weld a ram-rod but could not get it together properly. At first they tried to weld it with copper, but it would not remain fast."

With regard to these references I would make the following remarks:—

Campbell impresses one as having been a better observer than Moffat, and he had very much better opportunities, as the country had not then been devastated by the Mantatese or by the Matabele. He

*This word may mean *melted* or *smelted*.—T. G. Trevor.

gives a careful list of the articles of native manufacture and trade at Kurachane, but does not mention tin.

Moffat's reference to the native smith making *brass* from tin and copper shows his ignorance of the subject he was dealing with. Moffat's second statement with regard to tin is quite explicit, but it is hard to know how he, in the face of his former statement, was competent to judge that the metal was tin and was of the very best quality. On this subject I wrote to Mr. Griffith, the Native Commissioner at Rustenburg, who is a perfect Sesuto scholar, and who can obtain from the natives whatever knowledge they have. Mr. Griffith replied as follows:—

> "All I have been able to discover is that the natives have mined for copper and iron, surface workings, but I have not been able to discover if they ever mined for tin. None of the natives whom I have spoken to know the word "moruru," but I am told that the flakes which fly from iron when it is beaten after heating are called "morudu." These were re-smelted and beaten into wire with which bangles were made. This became much lighter in colour than ordinary iron. I have seen a native from Louis Trichardt district, who informs me that he knows for a fact that natives used to extract a white metal from stone, smelt it, draw it, and then draw it into strips of wire, from which they made bangles. The various metals had no distinctive names, they were all called tsipi—red tsipi, copper; black tsipi, iron. From all I can gather no serious mining was carried on by the natives."

That the reference in Louis Trichardt's diary to tin and copper had to do with the metals obtained from natives is possible, though improbable.

Portuguese Records: The references to these in Mr. Baumann's paper are so complete that I have not found anything to add to them.

II.—Later Observations:

In my opinion, it is quite impossible to get to the bottom of this question of ancient workings in South Africa by confining enquiries and observations to one group of workings. Everything which may throw light on the past inhabitants of the country should be recorded, and for this object of record I now submit the following discursive notes of various observations, many of which may now seem to have nothing to do with the ancient Rooiberg tin mines, but which, nevertheless, may each be found to fill a place when the jig-saw puzzle presented by the question comes to be built up to completion:—

(*a*) Beyond the tin ingots found at Rooiberg, and the fragment of bronze from the same locality, I have only succeeded in finding one small fragment of bronze and one fragment of a broken tin bangle in the country. These were dug up at Agatha, in the Pietersburg district. As white farmers almost invariably reside on the same ground which was formerly occupied by big native kraals, and cultivate the same ground, it is curious that neither tin nor bronze ornaments or implements ever seem to be disinterred. It is quite common to disinter skeletons. Both iron and flint and copper and brass implements or ornaments often come to light and have been brought to my attention, but only in the one case mentioned have I seen bronze or tin.

(*b*) *Zinc*.—The vast majority of ornaments worn by the elder natives are of brass. The ornaments themselves are usually obviously of native manufacture, but the origin of the brass is to me a matter of doubt. Formerly I considered that it must be imported brass, reworked into its present form by the natives, but latterly I have had some curious evidence on this point. In 1914 a farmer noticed a native woman wearing the neck ring which I exhibit. The woman's husband told the farmer that he had assisted his father to make this ring, and volunteered to point out the mine from which they had extracted the ore. He showed a very small old working which, on being opened, contained some copper minerals but no zinc, yet on drilling the neck ring I find it to be made of brass. Taken by itself, this incident has little significance, but on three occasions in the locality of the Pilandsberg I have been shown rough ingots of zinc, said to have been dug up in old native kraals. Formerly I did not believe this, and thought that the zinc had been imported and used by the old Boers for hardening bullets, but Mr. Harding, a resident in whom I have complete confidence, assures me that such ingots are dug up, and I cannot find any evidence that zinc was used for the purpose named by the Boers. In 1918 the ingot, which I exhibit, which weighs about 15 lb., was found in a

cave near Tjuenies Poort. The Chief Mapathelela claimed all the other things found in the cave, but had no interest in the zinc, which he said came from the East and was previously used by their smiths, but about which he did not seem to know anything else.

Hall, on page 72 of his book *Prehistoric Rhodesia*, quotes from three Arab authors:

(1) Edrisi, who writes in the twelfth century: "In all the country of Sofala they find gold in abundance, but prefer brass, making their ornaments of it."

(2) Omen Ibn I'Wardi, writing in 1200 A.D., alluding to East Africa: "The most remarkable part of the country is its quantity of native gold, in spite of which the natives adorn their persons with ornaments of brass."

(3) He also refers to an author Musoudi as writing in 915 to the same effect.

(*c*) *Ruins.*—At Mapathlela's Location, near some very extensive ancient workings, and on the farm Haakdoorndraai No. 41, some 20 miles to the south, I am informed both by natives and white men that bricks are ploughed up. These bricks are said to be flat and square, quite different to those made by white men, but I have not yet been able to visit the spots, though I believe the evidence to be reliable.

While on the subject of ruins it is interesting to note that no one seems to have observed the similarity of the two towers in the ruins of the Zimbabwe to the two altars which are erected by the Bapedi—and possibly by other Sesuto speaking tribes—on the occasion of their circumcision ceremonies. These are usually destroyed immediately the ceremonies are finished, but I have seen them on three occasions. In each case there were two altars—the one about breast high on a man, the other waist high. On the top of each fires had been burnt. The top in each case was under a foot in diameter and the base about 2 ft. 6 in., the sides descended in a curved batter, exactly as do the sides of the Zimbabwe towers. The smaller altar stood to the north of the larger one, as is also the case at Zimbabwe, though this may or may not have been intentional.

(*d*) At the Trappist Monastery at Pinetown a gold coin, undoubtedly of Phœnician origin, was dug up at a depth of 15 ft. in excavating for the foundations. This coin is in the Museum of the Monastery and can be examined. I have seen it, and it appears to be perfectly genuine.

(*e*) *Beads.*—(1) About ten years ago some beads were discovered in an old native pot in the old workings in the Messina Mine. These beads have been submitted by Mr. Gubbins, of the Marico, to Professor Flinders-Petrie, who, I am informed by Mr. Gubbins, states that they were a variety of beads which were introduced into the Roman Empire in the fifth and sixth centuries.

(2) In 1916 I found some beads in exploring a rock cave at Messina, and almost at the same time some beads were also found in one of the ancient workings. I submitted both parcels to Dr. Peringuey, of the South African Museum, who sent me the following report on them. It will be noted that the cave beads appear to be much more recent and typically "native" than the mine beads:—

"Pressure of work has prevented me acknowledging receipt of the two lots of beads, and to report on them is not an easy task. Nor, I am afraid, can I throw much light on their origin, and I fear that both Mr. Trevor and you will be disappointed. The lot marked "A" from a cave on a kopje on the eastern boundary of the Messina township contains (1) a piece of ivory bored lengthwise and with part of a spiral groove on the outer part; (2) small blue and red glass beads, most probably of European manufacture, and facetted blue bead, plainly also of European manufacture; (3) three ostrich egg-shell, flat disc-like beads of native manufacture (Bush).

"I would not have hesitated on account of the presence of the latter to ascribe the occupation of the cave to Bush people were it not that it is a well known fact that the Bush people of the Kalahari and neighbouring regions were in the habit of manufacturing these egg-shell discs not only for their own ornaments, but also traded them with the Damaras, by whom they were mostly used for making the corset-like belts worn by women of either wealth or position. These waist-bands built of several tiers consist of many thousand discs, but as far as I know these discs are, however, of a much larger size.

"The Bechuanas, on the other hand, wore ornaments of ivory, a fashion borrowed possibly also from the Bush, but, although I have not seen any in our collection that could compare with the one sent,

the style is identical. On the other hand, Daniell or Jansen, I forget who for the moment, has figured a Hottentot chief wearing round the waist similar ornaments of ivory. That the Hottentot women and children bore round the waist and arms strings of egg-shell beads is proven by my personal finds in sites and on bodies, but these beads are even at times smaller than those of the lot marked "A." For explanation as to their making, and to the tools used, I must refer you to Vol. VIII. of the South African Museum Annals. There you will also find that on the occupied sand dunes and middens of the Cape Flats round Capetown were found three or four glass beads of the same style as those in "A," and also bowls of clay pipes of the English and Dutch patterns of the epoch, with the stem broken off at the bowl, so as to inhale the smoke Hottentot or Bush-like fashion. These beads and the pipe bowls plainly imply that they were obtained from the early colonists, circa 1650. I think that the parallel need not be drawn further, and I leave it to you to imagine Bush from the Cape roaming as far as the neighbourhood of Messina from the extremity of the Cape Peninsula, or Bechuana or Lichtenburg Bantu having obtained the "A" finds from both Europeans (indirectly) and from Bush people (directly) as in the manner of the Damaras.

"The lot "B," found in an ancient copper working, does not, I am afraid, lead us very far towards the elucidation of the identity of the workers or their chronological date of existence. But the beads are very remarkable. The blue glass are of a type other than any we have in our collection, which is, however, no criterion. The annealing of these beads is also very primitive. I am still seeking information. But the two large orbicular beads are of great interest. From chemical test I was induced to consider them as having been made by turning, or lathe work of a primitive kind from large sea shells, as the test indicated lime carbonate. And on this false assumption I began to examine from large specimens the possibility of cube of similar sizes being obtained from certain sea shells occurring on the East Coast of Africa. As pieces of large conus are known to me as extremely valuable ornaments. We have several in our collection (*vide* also Livingstone's travels). Moreover, the use of the Cowrie shells as money is well known. But on second examination, by a geologist this time, the two beads are found to consist of quartz and limestone combined. So that, if they were made locally, it is for you to try and find where such formation obtains. Anyway, the theory of the sea shells as a material must be dismissed, although the huge Tridacna found in Mozambique cretaceous deposits are of sufficient thickness to allow of the production of cubes that would permit of the reduction to orbicular beads of a size similar to that belonging to lot "B," but the perforation of these beads is somewhat primitive, and although the nearly straight boring seems to imply the use of the bow-drill, yet the initial surface borehole is very faulty. I had occasion to compare initial borings of similar globular objects. I am not sure that I have arrived to safe conclusions. Primitive people perforated first on one side, and then started again on the opposite side of the piece, with the inevitable result that the apertures are never exact, except perhaps at the point of junction, when the perforated object is more than 2 or 3 mm. thick. But the narrow bore of the beads sent imply nevertheless a mechanical apparatus, no longer primitive in the shape of short hand-drill, but a mechanical one of the bow-drill type, because the two apertures are if anything only very slightly wider than the inner groove, whereas if it had been made by hand-drill, the two apertures must of necessity be wider at the openings owing to the wider rotary movement the turn of the human wrist would be subjected to in the process. This assumption of a drill apparatus necessarily implies that of a workman versed in its use and leads to the rejection of primitive people like the Bush as the arte-factors. You may perhaps remember the sketchy version I gave you of the Zimbabwe archæological remains in our Museum, also of the corroborative evidence of the age of the beads found there, as well as of that of the china. But on these two beads I cannot offer for the time any explanation. I said purposely for the time, as I am not going to let the investigation drop there, and I would be most thankful if more material were obtained. A skeleton, skull in preference, would prove sufficient to give us the true clue to the relics. Ask Mr. Trevor to try and obtain it or them.

"And while I am penning this discursive article I am reminded that Dr. Seligman,

of the London University College, sent me lately for report discs similar to but a little larger than the widest Kalahari ones, which he found in his Sudan excavations, also one or two other round beads, which unfortunately I pronounced at the time to be unlike anything found or known in or from South Africa, but without making figures or casts of them. The discs I found to be made of limestone, but perforated in the centre in the manner of ours. In some early Neolithical sepultures in Spain, where as far as is known now ostrich did not occur in pleistocene or miocene times, discs of the kind found in South Africa have been found. The Sudan limestone discs would thus form a transition from the Bushman industry. But did this industry originate in the north or in the south of the African continent? Did the Bush invent this industry while residing in Northern Africa, and when pushed towards the south, finding the ostrich shell more easily worked than the calcareous stone, use it instead? Or, and this seems to me the more acceptable hypothesis, did they not start from the south and in pursuit of the ostrich among other animals reach the extreme north of the African Continent and beyond? So far, ostrich shell discs have not been found in the wooded parts of the Congo or any other locality where ostrich do not occur."

(*f*) The Bapedi or Sekukuniland attribute all the old workings in their country to the "Mapalacata." According to legend these "Mapalacata" appeared from over the Drakensberg. They had black beards and wore clouds on their heads. They brought no women with them, and made their headquarters at D'Sjate, and were eventually wiped out by the Baroka, who then occupied the country. About eighty years ago, in the time of old Sekukuni, it is said that about forty guns were discovered in a cave at D'Sjate. These guns are said to have been very long, and are attributed by the natives to the Mapalacata. The natives could not make them fire, and eventually they were cut up to make hoes for the chiefs' wives. The native who cut them up was still alive and was pointed out to me when I first visited the country.

(*g*) In the year 1896 the late Mr. W. Leathern, of Natal, asked me to go down to Zululand and see a lot of "gold" bangles which had been disinterred on the banks of the Umvolosi—the White Umvolosi, I think. I did so, and found that some 500 lb. in weight of broken brass arm and neck rings had been found. These were obviously of European manufacture, and on looking the matter up I found that in the eighteenth century such rings called "manillas" were one of the chief articles of native trade exported from England for the markets of Africa and the East. From the natives Mr. Leathern learnt that some time about 1820 an epidemic called "the sickness of the pigeon" had visited the country, and that the doctors had ordered all such ornaments to be destroyed. This account tallies very fairly with the legend given by Mr. Gray.

(*h*) After a very large experience of old workings in all parts of the country and of Rhodesia, I would strongly emphasize that I cannot see any difference in skill or in method of working between one and the other. Where a regular reef was worked, as at Lulu, regular work was possible and was executed. Where irregular deposits, such as those at Rooiberg, were worked, the working was equally irregular, but I see no evidence at all for imagining that the one set of mines were worked by a different race or at a different period to the other set. In my opinion, all the greater workings from the Zambesi to the edge of the Transvaal High Veld are attributable, as far as the evidence goes, to the same workers, though the actual work must certainly have extended over long periods of time.

(*i*) The fact that no inscriptions or other record of high civilisation have been found has been used to discredit the theory of the Semitic origin of the workers, but to those who know the methods by which the Arabs (who are just as Semitic as the Jews) exploited Africa, this is not strange. A description of these methods may prove of interest. All the aristocratic families of Zanzibar, and I believe also of the Muscat coast, had their traditional family raiding territory. At intervals the chief, or one of the cadets of the family, led an expedition, consisting of a few of his relations, a number of freed men, and a large number of slaves, into that territory. They took with them on these expeditions neither their own women nor their priests, but merely fighting men and porters to collect tribute, slaves and plunder from the natives. On leaving, they issued a certain number of arms and ammunition to such of those natives as they trusted, with instructions to have so much ivory and so many slaves,

etc., ready for them the next time they came. If these were produced next time, well and good; if not, the kraal of these natives, and even the natives themselves, ceased to exist—they were wiped out. Occasionally these raiding parties settled in the country and did not return to their base. In these circumstances they very soon bred out and became almost indistinguishable from the natives, and hence left little or no trace of their civilisation. It is fair to presume that the inhabitants of the Muscat coast have pursued this policy from time immemorial, and if their ancestors, the Sabeans, were, as has been suggested, the original workers of the South African mines, those mines were probably run in that manner. Skilled freed men and slaves might have been left permanently to direct the natives, but no civilisation would have been introduced that would not have vanished in a few generations. This would explain the fact that though the plan of Zimbabwe and much of the ancient work appears too great for native organisation, there is no point of detail in them which the ordinary native of to-day could not accomplish. The only conclusion at which I can arrive from the present evidence is that the East Coast of Africa, from Delagoa Bay and upwards, has been in touch, direct or indirect, with the civilized nations of the Near East from time immemorial. It need be no matter of surprise, therefore, to find relics of those civilisations of any age scattered throughout the continent, though which nation introduced and chiefly profited by the working of the mines, there is not yet evidence enough to determine.

Mr. C. J. Gray *(Member of Council):* Since I contributed to the discussion, Major Swinburne has drawn my attention to a book "Vasco da Gama and his successors, 1460-1580," by K. G. Jayne, from which some extracts may be of interest:—

Page 40, re beachranger Hottentots found by Da Gama at St. Helena Bay, north of the Cape in 1497: "The Roteiro describes them as a tawny folk, clad in skin karosses and wearing sea shells or bits of copper as earrings." Page 41: "The natives showed no interest in samples of gold or cinnamon, though they grasped eagerly at such baubles as tin rings and bells." That statement indicates those natives appreciated tin, and is consistent with an idea that they had seen it before.

Page 43, 1498: "The fleet was compelled to turn eastward again and put in at the estuary of the Limpopo. A crowd of Bantu, both men and women, had gathered on shore" . . . "The Roteiro notes that weapons of the Bantu were long bows and arrows, iron-bladed assegais, and daggers which had ivory sheaths and hilts decorated with tin. The people wore copper ornaments, and for this reason Vasco da Gama named the Limpopo, Rio do Cobre, "River of the Copper.'" That is a distinct mention of tin at the time of the first European voyage to the place.

Page 50, 1498, re a visit of the Raja of Malindi to Vasco da Gama's ships: "Curiosity overcame fear, and he was rowed out to the ships, royally attired in a damask robe trimmed with green satin, and an embroidered turban. His dignity required the support of two cushioned chairs of bronze. . . . . In this state the Raja made a circuit of the Portuguese ships, while the artillery fired off salvos in his honour." Malindi is far to the north, and clearly the Raja may have obtained his bronze chairs with his clothing through Arab trade, but the extract has some interest as a reference to bronze in Africa south of the Equator in early times.

In connection with Mr. Trevor's remarks on discoveries of glass in the Transvaal, mention of somewhat similar discoveries in Natal may be made. When I was stationed in Maritzburg a few supposed precious stones, found in washing the sand of a stream from the Drakensberg near Himeville, were brought to me for identification. They were deep cobalt blue in colour and thoroughly waterworn and rounded, but proved to be glass. Subsequently an exactly similar blue stone, discovered in sinking a turbine pit in the bank of the Tugela, near Colenso, was brought to me. If I remember correctly, it came from a depth of 25 ft. in gravel, but it also was glass.

Mr. H. R. Adam *(Member of Council):* In connection with Mr. Trevor's remarks on brass ornaments, I am not quite clear as to whether he had come to any conclusion with regard to the source of the zinc. It may be of interest, however, to mention some ancient workings in the Low country where zinc and copper occur together. It is not impossible, I suppose, that such ore was smelted direct to a kind of brass. The samples I examined were much too high in zinc

for an ordinary brass, but the material taken from the surface workings may very probably have been much richer in copper. There are numerous signs of primitive smelting in the way of slag, but I have never found any actual metal.

Mr. Trevor: Down in the Leydsdorp Murchison Range?

Mr. S. Newton *(Member).* Might I ask if Mr. Trevor has ever heard of the Ancient Ruins Company, which was formed in Rhodesia in 1895? In the same year I was prospecting in the Shangani district on ground held by the Bulawayo Syndicate which is close to the farm "Leechdale." We heard that remarkable finds of gold ornaments had been found by Messrs. Radford & Leech, who were farming and prospecting in that district. Where and how they were found was secret until a company was formed called the Ancient Ruins Company, which was granted the right by the Chartered Company to search the old burial grounds, and I believe large quantities of gold ornaments of every description were found, the Rt. Hon. Cecil John Rhodes buying a big parcel of them. Whether the Chartered Company has any records on the subject I cannot say, but when the ornaments were found on such a large scale and must have actually been taken from the remains of those that wrought and wore them, then one great opportunity was lost in determining who and what race they represented.

Mr. T. G. Trevor *(Member):* I remember the Ancient Ruins Company well, but at that time I was very angry with the Chartered Company, as I had been more or less hounded out. I had gone to Zimbabwe myself in the year after the occupation, and they arrested me and took me to Victoria; they confiscated some 22 oz. of gold and some amber beads which we had got out of a grave. So I came back to the Transvaal. Outside the west gate of Zimbawbe there appeared to me to be an area some 30 yards in diameter, in which about knee-deep below the ground there was a layer containing human teeth and knobs of thigh bones in which many little gold "tin-tacks," just like the brass-headed nails which women use to tack round a bracket occurred. The amount of gold mentioned was, however, mostly obtained from one grave down the Sabie River; apparently the corpse had been buried between two mats and had worn a wooden breast plate ornamented with these gold "tin-tacks," but the wood had cracked so that it was quite tiered.

Mr. T. P. Waites *(Member):* I was much interested in one remark made by Mr. Trevor in his most instructive paper, which contribution to the discussion is equally as interesting, if not more interesting, than Mr. Baumann's original paper. He touched on one point which, to me at any rate, is of great interest, and said something to this effect, "that the Arabs are as much Semites as are the Jews." Well, having some time back read up as much as I could lay hold of on the origin of race, I opine that Mr. Trevor would be quite correct in saying that the Arabs are, as far as we know, the true lineal descendants of what we understand as the Semite. I have not yet found any authority who says distinctly and definitely what a Semite is, but, as far as my reading does carry me, a Semite is a cross between a white man and a negro. I give you as my authority one of the men who started this dispute or controversy, Count Gobineau, a very learned Frenchman ("The Inequality of Races"), who was laughed at many years ago when he published his work. It seems to me we use the word "Semite" as we use the word "Aryan," to account for something which we cannot actually fathom, in the same way that scientists use a "working hypothesis," to get at the bottom of these questions as far as we can.

In respect of the Jew, he is only half Semite, even if he really be so much as half. Will you permit me to go into this question for a few minutes? He migrated from Southern Arabia and first came into touch with civilisation at Ur, an outpost of the Accadian Babylonian kingdom. Some authorities are of opinion that the Semite here intermarried with the Accadian. Thence perforce following the Euphrates he travelled with his flocks further north and settled in Padan Aram—Mesopotamia—where he came into contact, and intermarried with, the Assyrian. The Hebrew is the result of the crossing of the Semite with the Assyrian. After a long residence in Mesopotamia these people migrated south into Canaan where they mixed with and intermarried with the Hittite. On this visit to Canaan they were guests, where, later, they entered the country as "conquerors"—from whom they inherit the Hittite nose. Thence travelling south they settled in Tanis, in the land of Goschen, and doubt-

less intermarried with the Egyptians. For instance, Joseph took unto wife a daughter of the priest of Heliopolis. Returning to Canaan they entered the land as conquerors—from this time we know them as Israelites. It is only since their return from captivity in Babylon under Nehemiah and Ezra that we know them as Jews, and their cult as Judaism. Semites, Hebrews, Israelites, Jews—I think we are justified in saying that these people are but half Semite, and I for one do not think it was the Semite, *i.e.*, the Jew, who supervised, say, the "ancient" mining in Rhodesia, Messina, or "the ancient tin mines." Were it so, we now have the same thing here—the natives working, some Europeans bossing the natives, and the Semite—if you like to call him such—financing the whole outfit. It is a case of history repeating itself.

As for the Arab, the true Semite, perhaps the purest race on earth, he has been settled here and there on the east of Africa from times immemorial. Tipu Tib devastated some 2,000 square miles of the interior—slave hunting. Still, I cannot call up any connection between the Arab and these "ancient tin mines." I ventured to remark in a contribution I made to this discussion that we have still to find some hard fact, such as a skull, before we can determine whether these ancients were brachycephalous or dolichocephalous—of the round or of the long, narrow-headed type. But to refer to the Jews as Semites is to beg a very large question. They are the result of many crossings — Semite, Assyrian, Accadian, Hittite, Egyptian, Amorite, and other blood go towards making up this remarkable human complex, but he almost in every instance bears in front of him his Hittite legacy, just as does the Armenian.

To me the question as to who these "ancients" were is just guessing as is to say they were this or that or the other. Until an "ancient" skull be found it must remain an open question

Mr. T. G. Trevor: With regard to this question of skulls, a hundred skulls might be discovered and not one recorded in the ordinary way, for scientific research in South Africa is not yet in its infancy. I might, however, mention the following with regard to peculiar skeletons which have come to light:—

(*a*) About the year 1892 I saw a very big skeleton which had been disinterred near some old workings on Malips River in the Pietersburg District. It appeared to me to be that of a man about 6 ft. 7 in. in height with a very big head. A Mr. Krudwig took possession of it and said that he was going to send it to Germany, and I heard no more about it. Mr. Krudwig is since dead.

(*b*) About the year 1897 it was reported in the press that two very big skeletons had been found about 70 ft. deep in the Monastery Diamond Mine, Ladybrand District, Orange Free State. The skeletons were said to be at least 7 ft. in height, and it was stated that they had been sent to the Bloemfontein Museum. Mr. David Draper wrote some sort of a report on the occurrence, but I never heard if anyone described the skulls.

(*c*) About four years ago a similar discovery of a very big skeleton was reported in the press as having occurred at Potchefstroom, but I do not think that anyone investigated the report.

(*d*) Curiously enough, only last night I met Mr. Salthouse, an old prospector of very great experience and credit. Talking about caves, he asked me if I remembered certain hills in the Mazoe Valley known as the "Iron Mask." In describing these caves he said that in one interior cave he found a blocked opening leading into another, on opening this he said he found a huge skeleton which he thought must have represented a man at least 7 ft. high. This was just before the Matabele Rebellion, and he did not know what became of the skeleton.

The above incidents seem to show that peculiar skeletons are found. It must be remembered that the original basis of all scientific knowledge is common observation, most of which of course is unreliable; but, in the present state of South Africa, we cannot expect more knowledge than we have—in fact it speaks very well for the powers of observation of our untrained population that we know as much as we do.

As to burial grounds, it is highly probable that the old inhabitants of Zimbabwe burnt their dead, for the Bavenda, who we know once lived at Zimbabwe still practice that custom.

Mr. C. J. Gray *(Member of Council):* Some years ago a skeleton was found in an extraordinary cave on the bank of the Insuzi River, in Zululand; I did not see it myself, but, according to my information, this small cave was apparently worked out of the quartzite and was very difficult of

access. I endeavoured to get hold of the skull, but apparently it had been neglected and thrown away.

The President: I feel inclined also to tell some stories about bones and caves; but I think it has got so late now that I shall have to close the meeting and leave the balance of the items on the agenda over to the next meeting on September 20th. At the same time I should like on your behalf, to thank Mr. Trevor very much for having troubled to come over from Pretoria and give us his very interesting notes. They open up an extremely interesting field of research for those who are fortunate enough to be able to travel about the country; and I hope all of you who do so will be stimulated by the line of investigation of which he has given you a hint.

Mr. Jas. Gray: Before we adjourn I should like to move a very hearty vote of thanks to Mr. Meyer for his services during his presidency, and I would like to couple with it the name of our retiring Treasurer, Mr. Littlejohn, and to Messrs. Toombs and MacDonald, who have also retired from the Council. (Applause.)

The President: Gentlemen, I am very much obliged. My term of office during the past year has been one of extraordinary interest and pleasure to me; nobody regrets relinquishing the office more than I do myself.

The meeting terminated at 10.35 p.m.

Review.

MINING ENGINEERS' HANDBOOK. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. First edition. 2,308 pages and index. Written by staff of specialists under the editorship of Robert Peele, Professor of Mining Engineering in the School of Mines, Columbia University. Price £1 3s.

This handbook is certainly the most complete of the kind ever issued, and its quality is guaranteed by a perusal of the list of sub-editors, among whom we notice J. F. Kemp, D. W. Brunton, R. T. Dana, R. H. Richards, J. E. Clennell, and others famous in the mining world.

It is obvious that a general handbook on mining matters must include a greater number of subjects than in any other branch of engineering, and the idea of obtaining specialists to handle the treatment of every section is one which must be highly commended, and undoubtedly enhances the value of this book. No less than 44 main headings are found in the table of contents, and it is difficult to suggest any subject with which a mining engineer is concerned that does not obtain adequate treatment. The aim has evidently been to supply such data on machinery, power plant and design as are necessary for those who erect mining machinery, as well as information on prospecting, exploration, mining, milling and ore treatment (including cyaniding and flotation) required by those who have to run the plants when erected. A useful feature is the provision of a bibliography at the end of each section.

The practice dealt with, though largely based on American precedents, includes many references to South African methods, and local works, including the *Journal* of this Society, are by no means ignored in the references given. Space will not permit of any exhaustive analysis, but one or two matters may be mentioned which could be improved in a later edition. The spelling generally is in accordance with English custom, but centre, nitre and colour are consistently treated as new American words.

Some of the references to South African costs and methods are a little out of date, *e.g.*, screening used and duty of modern heavy stamps are given as 0·033 in. aperture and 8·9 tons, while cost of ore reduction and percentage of extraction are not later than 1910.

In details of dressing amalgamated plates the use of a weak cyanide solution is advocated, though that bad old practice ought to be forgotten by now.

Among oxidizing agents having a beneficial effect upon the solution of gold by cyanide are mentioned K_2SO_4, K_2CO_3, Na_2SO_4, and it is curious that such obvious blunders should have been allowed to slip through in the short but very good account of the cyanide process.

That so few errors have been noted speaks volumes for the care with which the editor has performed his task, while the neatness of the illustrations and the clearness of the text display a very favourable example of modern typographical skill.

H. A. W.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Separation of Hydrochloric Acid from Iodates and Bromates, etc.—"The methods described are based on the property possessed by potassium hydroxide of attacking silver bromate and iodate, whereas silver chloride, bromide, and iodide remain unchanged. The solution to be examined is treated with silver nitrate solution in presence of nitric acid, the precipitate being collected and washed and then digested for some minutes in the cold with the alkali hydroxide solution; silver bromate and iodate are thus transformed into the corresponding soluble alkali salts. The liquid is filtered and the precipitate thoroughly washed, and tested for chloride, bromide, and iodide in the usual way. To test the filtrate for bromate and iodate ions, it is acidified with excess of hydrocloric acid and treated in a test-tube with one of 2 cc. of carbon bisulphide, sulphurous acid solution being then carefully added, drop by drop, and the whole vigorously shaken. In presence of bromic acid the carbon bisulphide becomes yellow or orange-yellow, and in that of iodic acid, violet. If both bromic and iodic acids are present, careful addition of the sulphurous acid reveals first the yellow colour of the bromine and afterwards the violet colour of the iodine. The presence in the original silver precipitate of salts of the cyanogen acids does not affect the reaction, since silver thiocyanate and ferrocyanide are not attacked by cold alkali hydroxide, whilst the cyanide is slightly attacked and the ferricyanide decomposed; when cyanide and ferricyanide are present, rather more sulphurous acid is added. The determination of bromic and iodic acids in presence of hydrobromic and hydriodic acids may be effected by employing the means of separation described above, the alkaline solution containing sodium or potassium bromate and iodate being then reduced with either zinc dust, or aluminium or Devarda's alloy (Cu 50, Al 45, Zn 5), and the bromide and iodide precipitated with silver nitrate in acid solution. If cyanogen derivatives are present, they must be removed, the procedure being as follows: the silver precipitate is calcined, the residue treated with dilute sulphuric acid and zinc, and the solution reprecipitated with silver nitrate: the precipitate then contains only bromide and iodide."—A. Purgotti. *Gaz. Chim. Ital.*, 1918, *48*, II., 63-66.—*Journal of the Society of Chemical Industry*, Dec. 16, 1918, p. 730A. (A. W.)

Determination of Phosphorus in Bronzes.—"Drillings of the sample (0·5—2 gm.) are digested with 10 cc. of strong hydrochloric and 20 cc. of strong, or, if preferred, 60 cc. of dilute, nitric acid (sp. gr. 1·135). The digestion must be sufficiently long to oxidise the whole of the phosphorus, but actual boiling and prolonged heating would cause precipitation of tin, which is difficult to re-dissolve. The liquid is diluted, if necessary, to 70 cc., cooled, and 40 cc. of ammonia (sp. gr. 0·96) added slowly with constant stirring, followed by 35 cc. of molybdate mixture. The liquid is shaken for a few minutes, allowed to stand for 1—2 hours, and filtered preferably through a pulp filter. The precipitate is washed with water until free from acid, returned to the flask, and dissolved in $N/20$ caustic soda; the excess of the latter is titrated with $N/20$ sulphuric acid in presence of phenolphthalein: 1 cc. $N/20$ NaOH = 0·00337% P on 2 gm."—T. E. Rooney, Inst. of Metals, Sept., 1918.—*Journal of the Society of Chemical Industry*, Oct. 15, 1918, p. 587A. (A. W.)

Corrosive Action of Flue Dust on Fire-Bricks.—"The corrosive action of flue dust on firebricks was investigated by injecting various dusts through a Brayshaw burner into a gas-heated furnace, the time of heating, the velocity of the flue dust, and the nature of the atmosphere being under control. The dust-charged flame impinged on the surface of the brick being tested. The 'dusts' used were a boiler flue dust of slate brown colour, a boiler flue dust of a brown colour, deep red-coloured dust from the top of the retort bench of a gas works, dust from the slag chamber between a steel smelting furnace and a regenerator, dust from a Blast-furnace Cowper stove, 'bull dog,' red hæmatite ore, tap cinder, lime from calcined marble, lime and common salt (1 : 1), salt, sodium sulphate, salt and potash spar (1 : 1), and sodium silicate and calcium silicate (1 : 1). The effects obtained under oxidising conditions were as follows:

Dust	Firebrick	Silica brick	Fine-grained silica brick
Boiler dust high in lime and ferric oxide ..	d.P. ; m.C.	—	—
Ferruginous boiler dust	s.P. ; s.C.	—	—
Ochreous dust from retort brick	k.P. ; S.c.	d.P. ; g.C.	—
Basic slag	d.P. ; S.c.	d.P. ; m.C.	—
Ferruginous dust high in lime	k.P. ; m.C.	d.P. ; m.C.	—
"Bull dog"	—	d.P. ; s.C.	—
Hæmatite (reducing flame)	—	d.P. ; s.C.	s.P. ; s.C.
Tap cinder	d.P. ; m.C.	d.P. ; m.C.	d.P. ; s.C.
Lime	s.P. ; m.C.	s.P. ; m.C.	—
Lime and salt .. .	s.P. ; m.C.	s.P. ; m.C.	—
Salt	d.P. ; s.C	s.P. ; m.C.	—
Sodium Sulphate ..	s.P. ; s.C.	s.P. ; m.C.	—
Salt and felspar ..	s.P. ; s.C.	s.P. ; m.C.	—
Soda-lime glass ..	s.P. ; s.C.	s.P. ; m.C.	—

Note—P = penetration; C = corrosion; s = slight; d = deep; k = complete; m = medium; g.C. = great corrosion or slagging.

The dust penetrates more readily into fireclay bricks than into silica bricks. The bond is usually attacked first and the coarser grains last. In fine-grained silica bricks, the depth of penetration is less than with coarser grained ones. Under oxidising conditions, iron oxide does not corrode silica bricks to any noteworthy extent, but under reducing conditions, ferrous silicate is formed and acts as a corrosive flux. 'Bull dog' dust and iron oxide generally corrode fireclay bricks more than silica bricks. The alkaline vapour in some dusts influences the conversion of quartz into a form of silica with a lower specific gravity. When the surface of a brick has been covered with a glaze formed by the action of the dust, the subsequent rate of corrosion is greatly diminished unless the glaze is sufficiently fluid to drip away, the corrosion is then rapid. Attempts to increase the resistance of the brick by applying a blowpipe flame to the surface were unsuccessful. The depth of penetration of the dust cannot be used as the basis of a quantitative measure of the corrosion."—J. W. Mellor and W. Emery, Ceram. Soc., Refractories Sect., Oct. 17, 1918.—*Journal of the Society of Chemical Industry*, Nov. 30, 1918, p. 693A. (J. A. W.)

METALLURGY.

Safety and Health in Hydrometallurgical Plants.—"Accidents to machinery or workmen in hydrometallurgical plants are usually to be attributed to a multiplicity of causes. Faulty design of plant arrangement and faulty estimation of power requirements for certain machines are often responsible. Other than in exceptional cases, no margin is allowed—no safety provision. Pulley and belting widths are often kept at a minimum consistent with theoretical requirements. When the mill starts, a cloud of dust coming from the rock-breakers, or raised by the injudicious or over-zealous use of the broom, finds its way between belt and pulley. Slippage follows, and is usually the forerunner of serious trouble, often culminating in personal injuries.

Reasonable Capacity Margin Desirable.—Under estimation of capacity needed is another potent cause for a condition of affairs that leads to trouble of many kinds. A machine that will carry the load only when favoured with unremitting attention is the cause of general inefficiency, owing partly to neglect of other units of the mill—a condition which often leads to minor accidents.

Cheap, second-hand, and often defective machines sometimes cost much more in the long run than a new and guaranteed item of equipment. Workmen are unacquainted with whatever hidden deficiencies and weaknesses are present, and accidents frequently result. The question of actual rather than of apparent economy should be considered in the first instance. If this is done, a liberal and expert estimate of probable cost for repairs and renewals will often sway the decision in favour of the unused and guaranteed machine.

Ample Space and Elbow Room Essential.—Space is usually the cheapest of commodities in a mining locality, and yet treatment plants apparently are often designed with an idea that the ground on which they are to be erected is almost priceless. Ample elbow room between dangerous belts and moving mechanisms is an imperative necessity if safety and comfort are to be considered and promoted. Compactness in design need not and should not involve a sacrifice of all elements of safety—or of any of them.

Congestion and crowding of equipment have been especially noticeable in the past in connection with cyanide plants designed by certain 'experts,' whose metallurgical concoctions were monuments to their ignorance of practical working conditions. In such plants the operator's patience was reduced to almost complete disappearance by the frequent necessity of having to crawl through indescribably dirty holes and narrow passageways to tinker with valves, or to assist in the flow of slime pulp which the designer of the plant had assumed would move under the influence of some law of accelerated gravity as yet undiscovered. In practically all such instances the designer could have prevented perpetual discouragement and annoyance, occasional injury, and ill health, by the use of a modicum of common sense, and the provision of adequate space and ample head room. This would have gone far to insure efficient control, and would have provided room for those minor modifications in arrangement usually needed in all chemico-metallurgical installations after the first run.

Operators' Point of View to be Considered.—One of the most important considerations to be kept in mind throughout the preliminary stages of the development of plans and specifications should be the provision of every possible incentive to productive effort on the part of those who will operate the plant, and the elimination of arrangements that may lead to discouragement of any kind, and which may result in the avoidance of, or in attempts to avoid, routine duties. The operator of the plant must be considered, and considered to the fullest extent from the outset. His attitude toward every phase of the work must be anticipated. His duties must be freed of tasks that are not required in a sensibly designed installation; and then, provided he has co-operated to the best of his ability, he will be able to hand over the plant, or section, at the end of his shift with the realization that the work has been well done, and that nothing has happened to diminish his enthusiasm. This should be the aim of the designer of the plant, who, if he knows what he is doing, has the power to influence the careers of the men who will work in his mill to a far greater extent than is usually realized.

Unproductive Effort Leads to Inefficiency.—Nothing is more detrimental to the general efficiency of operations than the presence of a perpetual irritant in the form of some disagreeable duty—disagreeable only because of the shortsightedness of the man who designed the plant. Nothing will occasion so much loss as when employees have a justifiable 'grouch.' This may arise from causes which those in authority cannot appreciate, such as many minor personal discomforts which often lead to illness or injury. What is needed is emphasis on the fact that plants are operated by human beings who are possessed of more or less keen susceptibilities. Keeping of this fact constantly in mind while designs are being considered is a prime necessity. If this was done in all cases, a great amount of discouragement would be avoided, less initiative would be stifled, and much unproductive effort would be saved for efficient purposes. A discouraged man is often an angry man, and an angry man is less likely to consider his own or another's safety—less likely to be able to make a wise decision in an emergency—than one who is contented with his surroundings.

Faulty Cost Estimation Often Leads to Unsound Economies.—The cost of plants is usually underestimated, and for a number of reasons that it is unnecessary to dwell upon. Toward the completion of erection work the most rigid economies are sometimes introduced; and everything that can be considered, by any possible stretch of the imagination, as not absolutely necessary, is eliminated. Satisfactory arrangements for dry walkways, substantial ladders, and broad stairways, insuring both safety and comfort, are thrown out as unessential, in conformity with an eleventh-hour policy of cheeseparing. Temporary substitutes are put in, and the promise of standard equipment at a later date is seldom fulfilled. Concrete flooring is often omitted, for the same reason; and the operator is sometimes expected to watch a daily waste of gold or silver in solution or other valuable product and at the same time maintain his enthusiasm for effecting economies in other directions. Such a policy is the worst kind of mistake. A good floor that can be kept clean and keeps itself drained should be the first consideration in a wet-crushing mill. It is no economy to neglect a provision that will add to health and comfort, to say nothing of the saving of the valuable metal effected. It is absurd to expect men to be enthusiastically respon-

sive to appeals to 'keep the place clean' when the most elementary precautions to encourage or insure this have been ignored in the original design of the plant.

In many cases the smallness of the installation is pleaded as a reason for the avoidance of what a large corporation would consider essential health and safety provisions. This excuse is not always legitimate, and is often made through adopting a mistaken policy of erecting a mill before the mine had been developed to a scale sufficient to justify the expenditure for an adequate treatment plant.

Manual Labour Economizing has Aided Safety Movement.—Dusting in a hydrometallurgical plant is usually confined to primary crushing, and the ill-effect on the health of the workers is small, due possibly to the fact that the dust usually contains a percentage of non-abrasive particles. The introduction of tubular mills of various designs has unconsciously aided the safety movement, inasmuch as their adoption has led to a greater simplification of operation, making personal attention less necessary, and so reducing the liability to accident. The economy in manual labour resulting from the use of mechanical devices such as crushed ore distributors and excavators has also resulted in a diminution in injuries, and an improvement in general health, by freeing a number of workers from monotonous and often unhealthful tasks.

Apart from those arising from the lack of safety provisions, the majority of accidents occurring in a modern plant result from unexpected causes. The relation of knowledge of danger to resultant accident is marked. The deadly nature of cyanide is well known, and poisoning from this cause, in spite of continual contact, is happily rare in most countries, and deaths from cyanide poisoning are so uncommon as to be almost negligible in number. Precautionary measures are now standard, and though in isolated districts, where it is impossible to convince natives of the danger, it is not uncommon to have a number of poisonings with 'green' gangs, all the cases respond to the antidote, which is kept handy.

High-tension current is well known as dangerous —the effects of a slight shock are not easily forgotten—but the number of accidents from this cause is comparatively small. Other dangers are more insidious and less obvious. Salivation, or mecury vapour poisoning, is not uncommon among amalgamation-plant workers—a condition that has often been improved by an educational campaign in the mill.

Safety Principles in Accord with Efficiency Programme.—On reviewing the situation it is impossible to avoid the conclusion that, in general mill work, the insuring of greater safety and better health has often resulted without a recognition of safety-first principles, *per se.* This proves the eminently sensible nature of the safety campaign, because the changes that have tended to reduce or eliminate danger and discomfort and increase security and satisfaction were concordant to a plan insuring greater efficiency in general results, made in the first instance to increase returns and decrease costs, or both. The resulting economy in labour diminished the likelihood of accident and freed workers for other less dangerous but more responsible tasks, and so aided the movement that has done so much to stabilize industry in general."—A. W. Allen.—*Engineering and Mining Journal,* Sept. 14. 1918, p. 480. (W. A. C.)

MINING.

Memorandum on the Preservation of Timber in Coal Mines.—"At the present time the shortage of timber supplies has rendered the prevention of wastage in pit timber a matter of national importance. A large amount of timber in mines, and especially in shallow coal-pits, requires to be replaced prematurely because it undergoes decay and consequently collapses. Such decay or disintegration is, at least for the most part, caused by various fungi which permeate and devour the wood, and often clothe its surface with a fluffy or cottony material ('spawn'). This spawn, usually white but sometimes coloured, can rapidly grow over the timber, walls or floor, and may even be broken off and transferred elsewhere, and thus reach and infect sound wood.

These wood-destroying fungi also produce fructifications, which emit countless microscopic germs ('spores'), which, conveyed through the air, may alight on, and attack, pit-wood.

Two means of preventing loss through the decay of wood are possible: *preventive* and *remedial* measures.

Thorough *preventive* measures are largely impracticable at present owing to difficulties as regards machinery, materials and skilled labour. On the other hand, *remedial* measures may be undertaken at once; and it is the main object of this memorandum to point out what they are, and how they should be employed.

A. *Remedial measures* are designed to decrease the amount of infection, so that the life of pit-timber will be *lengthened on the average,* and a corresponding saving be thereby accomplished.

Growth of the spawn over the surface of the timber, walls or floor to sound wood is one means of rapid spread of infection, and is aided by the transference of the spawn by other agencies (wind-currents, on men's clothes, packing of rejected pit-wood close to sound wood, etc.). The checking of this superficial growth cannot do more than diminish the rate of decay of the timber, because the wood-attacking fungi grow also inside the timber; but inasmuch as the fungus grows more rapidly outside than inside the wood, the rate of destruction of pit-wood will be decreased by killing spawn on the surface.

Infection will likewise be decreased by the removal and destruction of the germ-producing fructifications that emerge from the wood.

In order to accomplish these ends—

1. Colliery timber men should be taught to recognise the spawn and fructifications.

2. *Starting from the intake,* and travelling with the air currents to the return ways, the timber should be periodically inspected for fungus-material on the timber. Where fungus occurs, the accessible pit-wood should be treated as follows:—

(a) The apparatus required would be a pail, some cloths, a cloth or cotton swab, a strong knife, and an antiseptic solution properly made up.

(b) The following antiseptic substances are suitable, and are arranged in order of preference:—

(i.) Creosote, and various derivatives.*

(ii.) Zinc chloride.

(iii.) Copper sulphate (which should not be used where the mine water is rich in iron).

(c.) Every fructification (shaped like a cushion, bracket or mushroom) should be removed by cutting away the portion of wood to which it is

*Competent advice should be sought as to these.

attached. These should be placed in the pail, carried to the surface, and burnt in the boiler fires. All waste timber lying in the roadways and recesses should also be brought to the surface and burnt at once. Instant burning is important, as a good deal of infection of sound timber takes place during storage above ground because decaying wood is allowed to lie about amongst it, and so the infection is spread to timber originally sound.

The result of this would be to stop much of the infection that is caused by microscopic germs (spores).

(d) At the same time or subsequently, the spawn on the surface of the pit-timber would be dealt with as follows. Each man engaged would carry a swab, the cloths and pail three-quarters full of the antiseptic solution chosen. All the accessible wood, including props, balks, crown-trees, bars and collars, would be washed with the solution, and the spawn removed. The solution and cloths would require to be renewed from time to time. When possible, loose bark should be removed and the bare wood washed over with the solution.

This treatment would serve both to check the growth of spawn over the surface and to prevent its transference from one part of the mine to another, and thus would hinder new infections. But a certain amount of the antiseptic solution would be absorbed by the wood, and on drying would leave on or near the surface a thin film of antiseptic substance which would check the growth of any germs that might alight on the wood.

A great deal will depend on the thoroughness with which these operations are carried out. When once begun the treatment should be systematically and regularly pursued, as these wood-attacking fungi grow rapidly and temporary neglect may undo the work of months. The mine-timber should therefore be examined at least once a month. The consequence of the treatment will be a steady improvement in the condition of the mine-timber from the very commencement. It will, however, be evident that one limitation to the beneficial effects will be due to the inaccessibility of decaying wood packed under the roof above the balks, crown-trees, bars or collars.

B. The methods detailed above constitute a *direct attack on the wood-destroying fungi*, and are designed to reduce the loss occasioned by decay in mines that are already infected. An entirely different method of dealing with the problem is a defensive one, and involves the *protection of the wood* by rendering it immune to infection by fungi.

Wood can be protected more or less perfectly from decay-inducing fungi by coating or impregnating it with an antiseptic substance. The degree of protection thus afforded depends upon the substance used and upon the depth to which it penetrates the wood. Mere superficial coatings are less efficient than injections to some depth within the surface; while perfect protection is ensured solely by impregnating the wood throughout.

Various substances are very unequal in their power of conferring upon wood resistance to fungal attack. In some coal-pits mere soaking with mine-water lengthens the life of the wood: at the opposite extreme of efficiency is creosote, which confers indefinitely long durability upon wood. The exact treatment to be adopted will depend therefore on the circumstances of the case and particularly upon the time during which the wood is required to remain sufficiently sound to be of service. Superficial washes are applied by means of a brush; and when this or any other method of application of the antiseptic is adopted, bark must be removed from the timber before treatment. Somewhat deeper penetration is ensured by soaking the wood for a longer or shorter time in the heated antiseptic solution. For this purpose, timbers, before being taken down into the pit, should be soaked for at least 15 minutes in a vat of 10% zinc chloride at a temperature of 130° F., or in creosote as hot as it can conveniently be used. When the props are put in position in the ways, their tops where bruised by the hammer should be painted over with the preservative, as infection often starts at these spots. For deeper penetration, more prolonged soaking is essential, and the deepest penetration is ultimately secured with greatest economy by pneumatic pressure (and the use of a creosoting plant) if large quantities of wood require treatment.

Creosote and its derivatives, or zinc chloride, represent the most economic and efficient antiseptics for use in mines. But a number of salts confer feebler resistance, and may be used where the wood has to last only a relatively short time before being removed; among these are common salt, magnesium sulphate, certain mine-waters, copper sulphate (not to be used where the mine-water is rich in iron); *iron sulphate*, sometimes recommended, *should not be used*.

This policy of replacing timber in mines by wood rendered more or less antiseptic should be followed in all cases. When carried out in the most thorough manner, it gradually brings the pit into a completely sanitary condition (for instance, thoroughly creosoted pit props that when unprotected collapse from decay in a few weeks will last for many years; discarded creosoted railway sleepers similarly will serve for indefinite periods as sound cross bars).

The precise method of dealing with mines in order to eradicate or decrease decay of timber will vary somewhat in detail in different cases. In regard to this, advice may be obtained from the Department of Scientific and Industrial Research.

Note.—The significance of wood attacking fungi (and possibly certain bacteria) is not confined to their destruction of timber, for during their growth they may produce 'black damp,' and the amount of this gas that they produce is directly proportional to their abundance and vigour."—PERCY GROOM.—*Bulletin*, No. 1. British Department of Scientific and Industrial Research. [W. A. C.]

MISCELLANEOUS.

FREE EXPORT AND SALE OF GOLD.—"Gold has been been sold in England at 115s. per oz., as against 85s. per oz. paid by the Bank of England for coinage purposes, and the Government found it necessary to prohibit the melting of coins. Gold under present conditions could be also sold at a premium in this country for use in industrial arts, and if a free sale of gold were now permitted a certain amount could be absorbed at a considerable premium. A study of the table on p. 33 shows that for the last four years about forty-five million a year, approximately one-half of the amount produced in the United States, went into the manufactures. Dentists use a large part of this gold, and could pay a higher price for it, as could also jewellers. The amount of old material—jewellery, etc.—consumed in manufactures in the United States has been approximately $8,000,000 worth a year, and of new gold, approximately $37,000,000 a year. The annual amount that could be absorbed

at a premium is not known, and would depend to some extent upon psychological conditions. If it were thought that the price of gold would go higher, quantities would be bought for speculative purposes unless restrictions were imposed. The following extract from *Bulletin*, Canadian Mining Inst., Oct., 1918, pp. 860-861, is of interest in regard to the sale of gold in the open market:

It seems to have been overlooked by many that the mint price for gold (85 shillings or $20.67) is quite different from the market value or exchange value of the metal. Gold as a commodity has had, this last month in England, a value some 35% in excess of the mint price. The *Annalist* tells us that minted coins have been at a high premium because of profiteering by labour. Workers are receiving wages higher than ever before in their experience, and there is a demand for jewellery which exhausts the supply of gold, the commodity. An ounce of gold in a jeweller's hands will make four rings, for which he will get at least $30; in consequence, the market price of gold in those countries in which gold has been commandeered is nearly 50% above the mint price. This is the fact that has led Sir Lionel Phillips and his committee to approach the British Government for permission to sell the gold produced by their mines in the "open market"; that is, sell it as a commodity."—Extract from *Bulletin* 144, Department of the Interior, Bureau of Mines, U.S.A., 1919; Report of a Joint Committee appointed from the Bureau of Mines and the United States Geological Survey by the Secretary of the Interior to Study the Gold Situation."—(W. A. C.)

Abstracts of Patent Applications.

177.18. Coalite, Ltd. Improvements relating to the destructive distillation of carbonaceous substances. 22.3.18.

This application relates to low temperature carbonisation in vertical retorts, and has for its object the converting of the rich hydrocarbons given off at low temperature into aromatic bodies, and for this purpose a space is provided at the top of the retort which is subjected to a comparatively high heat, and in this space a mass of metal or fireclay is suspended to increase the heating surface, and, further, the heat is applied to the retort in several zones increasing in temperature from the bottom to the top.

200.18. J. McCrindle. Safety finger wedge for stamp mills. 28.3.18.

This application relates to improvements in "safety finger wedges for stamp mills," and consists of a hardwood wedge to be placed between the finger and the cam floor, and is locked in position by a hook bolt engaging the bottom of the finger socket.

237.18. Harry August Stockman (1), Alexander Proudfoot (2). Improvements applicable to pillars and similar supports for mine workings and the like. 17.4.18.

This application refers to the construction of pillars for underground workings, consisting of an outer casing, the interior being filled with a compressible core.

There are nine claims in the specification, and the description confines itself to circular pillars made of concrete bricks, plain or reinforced, with a filling of stone, sand, slime and saw-dust in any combination, and also to the use of compressible mortar.

377.18. Albert François. Filling spaces or cavities which are difficult of access with concrete, cement, or the like. 4.7.18.

This application refers to the filling of cavities which are difficult of access with concrete, the object being to accomplish this in a rapid and economical manner.

637.18. W. E. Nettle (1), P. Selby (2), J. Blythe (3), J. H. Holman (4). Improvements applicable to reciprocating rock-drills for supplying water to the bore holes during drilling. 18.10.18.

This application refers to the water feed arrangements, using hollow steel with the reciprocating drills, and describes in detail the method by which this is to be effected.

705.18. Luckenbach Processes, Incorporated. Composition of matter and methods of and apparatus for using same. 23.11.18.

This application is for a process and apparatus for concentrating ores and materials. The inventor calls the process a contact process to distinguish it from the flotation process. The selective materials used for recovering the desired minerals are rubber, resin, shellac, asphaltum or pitch. All these to be dissolved in a water repellant solvent. The preferred selective agent is petroleum grease and dissolved rubber. This mixture is put on a surface of a moving belt or rotary table or on a mat of thin shavings in the form of a thin coating; the material to be concentrated is passed in the form of a pulp over any of these prepared surfaces the minerals coming into contact with the said surfaces, adhering, and the gangue passing away as tailings. The mineral concentrated or caught in this manner is recovered by separation from the surface coating by means of boiling in hot water, or other methods.

The applicant claims the use of various apparatus for effecting his purpose, such as continuous revolving belt, revolving table and trays filled with shavings.

Changes of Address

Angus, T., *l/o* Wankie; Slaaiboek Mines, P.O. Airlie, Eastern Transvaal.

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Maclatchy, A. G., *l/o* Balfour; East Rand Gold, Coal and Estate Co., Ltd., Vischkuil, P.O. Endicott Station.

Pearce, J. W., *l/o* Belingwe; Nil Desperandum Mine, P.O. Shabani, Southern Rhodesia.

Thomas, F. J., *l/o* Beatrice Mine, Salisbury; Wolfshall Mine, Selukwe, Rhodesia.

Watson, John, *l/o* Calcutta; The Magadi Soda Works, Budge Budge, Bengal, India.

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(COMPILED BY THE SECRETARY, MR. FRED ROWLAND, F.C.I.S.)

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